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ASTRONOMY SECTION OF THE A. A. A. S.
(Report of the Cleveland Meeting)

By PHILIP FOX.

The Cleveland program of Section D was the most extensive that has been presented without the presence of the affiliated American Astronomical Society. The attendance, which averaged about fifty, was also gratifyingly large. Dr. D. W. Morehouse, Vice-president of the Section, presided at all meetings.

Perhaps the most important astronomical event of the year, certainly the most dramatic, was the discovery of the planet Pluto at the Lowell Observatory. Various papers on the program of Section D concerned this planet. Nicholson and Mayall find the period to be 247.7 years, distance 39.46 A.U., perihelion passage 1989, eccentricity 0.25, and the mass 1.08 times that of the Earth. From a study of widely discordant preliminary determinations of the orbit of Pluto, Dr. Bartky derived some new and important general equations expressing the probable errors of orbital elements in terms of the probable errors of the observations. On Wednesday evening Roger Lowell Putnam, Trustee of the Lowell Observatory, in a general session reviewed the whole Trans-Neptunian campaign in an illustrated lecture, "Searching out Pluto, Lowell's Trans-Neptunian Planet." It is interesting to see that this discovery was truly an institutional enterprise in which many participated and to see how the progressive refinement of orbital elements has led to the discovery of images of the planet on plates earlier than those of the discovery date, on plates of 1918 at Mount Wilson and of 1915 at the Lowell Observatory.

The approaching important opposition of Eros was the basis of a paper by Seares, Sitterly, and Joyner, who have investigated the magnitudes and color indices of the comparison stars. They point out differences of color-coefficients and scale correction of various observers.

The Leonid meteors were so abundant in the early morning of November 17, 1930, that there is indication of a spectacular shower in 1932 or 1933. Morgan and Calvert report their observations which at the maximum gave 187 per hour. A new general estimate for the number of meteors is given by C. C. Wylie, who derives the figure for those which strike the Earth's surface and which would be bright enough to attract attention, as 20,000 annually.

Three papers dealing with the Sun concluded those bearing on the solar system. Alter presented a study by the method of correlation periodograms of the Planetary Tidal Hypothesis and Variation of Sun-Spot Activity. Extension into the future will test the validity of the conclusions which seem decidedly interesting. Stetson continues his observations on the close correlation of the intensity of radio signals with the sun-spot curve. The best reception was in mid-summer close in the wake of the low ebb of solar activity of the first part of July. His results led to a preliminary discussion of certain electronic theories now under consideration. Josef Johnson gave a preliminary report on the Solar Eclipse of 21 October, 1930, as observed at Niuafou. Especial attention was directed to the intensity of various parts of the corona.

In the field of spectroscopy there was a group of interesting papers. Miss Payne presented a spectroscopic study of the Scorpio-Centaurus cluster. She emphasized the need of interpretation of the discordances in the character of the lines of the spectrum. In stars of the same type one may have strong lines, another weak; one may have sharp lines and another hazy. Pressure and stellar rotation were discussed as causes. The important paper by Struve and Elvey on Stellar Rotation came as an apt sequel to that of Miss Payne. The authors discussed the causes that produce broad, ill-defined lines and ascribed the effect to stellar rotation. From the contour of the lines they deduce rotation periods and find that equatorial velocities of 250 km/sec are not exceptional. The method was checked by observing the eclipsing variable Algol by the method discovered by Schlesinger and used by McLaughlin and substantial agreement was found.

As series of observations of spectroscopic binaries are extended, the possibility of detecting the presence of additional bodies increases. Miss Losh finds that the velocity of the center of mass of Zeta Tauri is variable with a period of 24.6 years and a range of 43 km. This long period variation may coincide with the changes of emission.

In eclipsing binaries there is often a discrepancy between the time of light minimum and the time of eclipse indicated by spectroscopic data. Carpenter suggests the consideration of the photometric observations, fitting in the time of primary eclipse, in the computation of the spectrographic orbit. A test case of u Herculis yielded gratifying results.

Bobrovnikoff identifies certain nuclear bands in the spectra of comets with the Raffety bands of the presumably CH molecule. The agreement is not complete. Variations of intensity with heliocentric distance reveal that the cometary bands form at least two systems. Frequency formulae give fairly good representation for certain of the bands with the CN molecule suggested as the carrier. The remainder are probably due to the CH molecule.

Berman has studied the nebular lines at wave-lengths 3869 and 3967. Their intensity ratio is approximately constant in various planetary nebulae. Certain considerations lead to the rejection of C^{++} as the source and the author inquires if P^{++} or Si^{++} are possibly available.

The photo-electric cell holds a place of increasing importance in astronomical research. It has now attained to high sensitiveness. Stebbins finds that the electric current produced in the cell by faint sources can be easily measured, the limit of detection being equivalent to a standard candle at about three miles. If the candle were as white as some stars it could be detected at double this distance. In the telescope the eye can perceive objects about two magnitudes fainter than the cell can detect.

The Eastman Kodak Company has prepared some new panchromatic plates whose characteristics were discussed by Mees. Their adaptation to visual refractors and their high speed will make them of interest to all engaged in stellar photography.

The remaining papers were brief. Mehlin's test of the Brashear objective of the Drake Municipal Observatory showed both visual and photographic combinations to be of excellent quality. MacMillan showed some ingenious stereoscopic pictures of star clusters. Dustheimer reviewed the astronomical Radio program of WTAM. This station has broadcast 62 astronomical talks in the last six years. The listeners use star charts and literature distributed from the station.

A joint session with Section L and the History of Science Society offered the following program: Galactic Explorations, address of the retiring Vice-president of Section D, Harlow Shapley; Historical Instruments in the Adler Planetarium and Astronomical Museum, Philip Fox; Life of Sir Isaac Newton, a Character Sketch, Louis T. More. The first and last of these will be published in full. In the second the author gave a brief survey of the Mensing Collection of Old Scientific Instruments which was acquired just a year ago. It contains examples of the work of the principal instrument makers of the sixteenth, seventeenth, and eighteenth centuries, Examples were exhibited and others were shown in slides.

Various members who attended the Cleveland meetings visited the Warner and Swasey Company, where so many of the great telescopes have been built, also the Warner and Swasey Observatory of the Case School of Applied Sciences, where the local representative for the Section, Dr. J. J. Nassau, received the guests. A third focus of interest was the interferometer house where Professor Dayton C. Miller continues the important observations of the ether drift experiments.

JANUARY 17, 1931.

GEORGE GRAHAM
Maker of Horological and Astrononical Instruments

By C. DORIS HELLMAN.

George Graham, a celebrated London horologist of the early eighteenth century, is of great interest to astronomers because of the important part he played in the progress of their science. It was Graham who made the instruments which, because of their remarkable accuracy, enabled James Bradley to discover two new motions of the fixed stars, namely aberration and nutation.

During Graham's life (1673-1751), the Royal Society, under the leadership of Sir Isaac Newton and other great men, was encouraging scientific research along all lines, and counted George Graham among its highly esteemed members.

George Graham was born of Quaker stock at Horsgill in the parish of Kirklinton, Cumberland County, July 7, 1763.

At an early age he lost his father and came under the care of an elder brother, William Graham of Sikeside. While still a boy he left Cumberland County and made his way on foot to London, where on July 2, 1688, he became apprenticed to the clockmaker, Henry Aske. In 1695, having completed his seven years of indenture, he was admitted a Freeman of the Clockmakers' Company.

Graham's excellent work while still an apprentice attracted the attention of Thomas Tompion, the famous horologist, and, immediately upon attaining his freedom, he was invited by Tompion to enter his services as journeyman. Later he married Elizabeth, the daughter of Tompion's brother, James.

Tompion died November 20, 1713, leaving his business to Graham by will. The *London Gazette* for November 28 to December 1, 1713, carried the following announcement: "George Graham, Newphew of the late Mr. Thomas Tompion, who lived with him upwards of seventeen years and managed his trade for several years past, whose name was joined with Mr. Tompion's for some time before his death, and to whom he left all his stock and work, finished and unfinished, continues to carry on the said trade at the late Dwelling House of said Mr. Tompion at the sign of the Dial and Three Crowns, at the corner of Water Lane, in Fleet Street, London, where all persons may be accommodated as formerly." There is still in existence at least one clock which bears the double mark of the two famous clockmakers, "Tompion Graham."

The relationship must have been of great value to Graham in many ways. When he was still a poor and unknown apprentice, Tompion was already well-established and influential, as is indicated in the following account of his life taken from F. G. Britten's *Old Clocks and Watches and Their Makers,* which describes him as being at the peak of his pro-

fession. "Thomas Tompion, 'the father of English watchmaking,' was born at Northill, Bedfordshire, in 1638. It is said that his father was a farrier and that he was brought up to the same trade, but the first reliable record shows him to have been in business as a clockmaker at Water Lane, Blackfriars, when quite a young man.

"Water Lane was a long, tortuous thoroughfare, the western portion of which is now Whitefriars Street, and Tompion's shop, known by the sign of the Dial and Three Crowns, was at the Fleet Street corner where the offices of the *Daily News* are. His advent marks a distinct epoch in the history of the horological art. Throughout his career, he was closely associated with some of the leading mathematicians and philosophers of his time. The theories of Dr. Hooke and the Rev. Edward Barlow would probably have remained in abeyance but for Tompion's skillful materialization of them. He soon became the leading watchmaker at the court of Charles II and was everywhere welcomed as an artist of commanding ability. When he entered the arena the performance of timekeepers was very indifferent. The principles on which they were constructed were defective, and the mechanism was not well-proportioned. The movements were as a rule regarded as quite subsidiary to the exterior cases, and English specimens of the art had no distinctive individuality. By adopting the inventions of Hooke and Barlow, and by skillful proportion of parts, he left English watches and clocks the finest in the world, and the admiration of his brother artists. Of course he did not reach finality; improvements continued under his immediate successors, . . . " important among whom was Graham. He held the highest offices in the Clockmakers' Company and was buried in Westminsted Abbey.

Graham not only was handed a business already built up, but through the prominence of his patron, had the opportunity of meeting the older of his contemporaries in the field of science with whom he would otherwise not have come in contact. For example, Robert Hooke, through Tompion, may well have aroused his interest in the barometer, which forms the subject of one of Graham's papers in the *Philosophical Transactions.*

That Graham was held in high regard by the men of his time is easily judged from the references made to him in their writings. The *Gentlemen's Magazine* for 1751, for example, contains the following notice in its "List of Deaths" for that year. "His temper was not less communicative than his genius was penetrating, and his principal view was not either the accumulation of wealth or the diffusion of his fame, but the advancement of science and the benefit of mankind. As he was perfectly sincere, he was without suspicion; as he was above envy he was candid, and as he had a relish for true pleasure, he was generous. He frequently lent money, but could never be prevailed upon to take any interest, and for that reason, he never placed out any money upon government securities; he had bank notes which were thirty years old by him when he died, and his whole property except his stock in trade was

found in a strong box, which, though it was less than would have been heaped by avarice, was yet more than would have remained to prodigality." This notice was later given verbatim in Hutchinson's *History of Cumberland County*.

In 1716 Graham was chosen one of the Court Assistants of the Clockmakers' Company, and in 1719 he became Junior Warden, the next year Renter Warden, then Warden, and finally Master in 1722. In 1720 he was elected to the Royal Society and in 1722 to membership in its council. He gave up Tompion's old house in Fleet Street in 1720 and moved to other quarters on the same street a little nearer the bridge, where he stayed until his death, which occurred November 2, 1751, exactly thirty-eight years after that of Tompion. The *Gentleman's Magazine* gives the following description of his funeral rites. "On the 24th at night, he was carried in a herse, preceded by three mourning coaches with the gentlemen who were to support the pall, and followed by nine, to Westminster Abbey and there interred in the same grave with the remains of his predecessor, Mr Tompion. The pall was supported by Dr Knight, Mr Watson, Mr Canton, Mr Short, fellows of the R. S., Mr Catlyn and Mr Bird, intimate friends of his."

Burial in Westminster Abbey was an honor not easily won at that time by a member of the middle class, and the grave of Tompion and Graham is a testimonial of the esteem in which they were held and of the growing interest in scientific matters. The grave is in the floor of the nave-center and is covered with a slab of stone bearing the following inscription: "Here lies the body of Mr. Tho Tompion who departed this life the 20th of November, 1713 in the 75th year of his age. Also the body of George Graham of London, Watchmaker and F.R.S. whose curious inventions do honor to ye British genius whose accurate performances are ye standard of mechanical skill. He died ye XVI of November MDCCLI in the LXXVIII year of his age."

At his death, Graham left a will, dated June 23, 1747, by which his wife was to receive one half of his personal estate, etc., and the Poor of the Clockmaker's Company the sum of twenty pounds. Thus he rounded out his life with that generosity which had always marked his actions.

* * * * *

The seventeenth century watchmakers utilizing Galileo's invention of the isochronal pendulum, and applying it to clocks, made possible the production of the famous seventeenth and eighteenth century English clocks.

Tompion, Graham's master, invented the first dead beat escapement for watches and also the cylinder escapement with horizontal wheel. As watchmaker to the King, he had ample opportunity to develop his ideas and his mechanical skill.

As a result of working with Tompion's dead beat escapement for watches, George Graham developed, in the year 1715, what is known as the "dead-beat" form of the anchor escapement, a "superior escape-

ment for accurate clocks." An ordinary anchor escapement violates the condition of the perfect escapement because the pendulum is never free, but at the end of its swing is still operated on by the escapment which it causes to recoil. It was to get rid of this defect that Graham invented the dead beat form of the anchor escapement which differs but little from the recoil form. By changing the form of the pallets the escape wheel is kept stationary.

With the increasing accuracy of clocks, the effect of changes of temperature on the running became more apparent and consequently troublesome. In 1721, George Graham invented the mercury pendulum, which was the first attempt definitely to get rid of the effect of temperature changes. He communicated his discovery to the Royal Society in an article published in the *Philosophical Transactions* for the year 1726, extracts of which are given here:

"A contrivance to avoid the Irregularities in an Clock's Motion, occasion'd by the Action of Heat and Cold upon the Rod of the Pendulum. By Mr. George Graham, *Watch-Maker, F.R.S.*

"Whereas several who have been curious in measuring of Time, have taken Notice that the Vibrations of a Pendulum are slower in Summer than in Winter; and have very justly supposed this Alteration has proceeded from a Change of Length in the Pendulum itself, by the Influences of Heat and Cold upon it, in the different Seasons of the Year; with a View therefore of correcting, in some degree, this Defect of the Pendulum, I made several Trials, about the year 1715, to discover whether there was any considerable Difference of Expansion between Brass, Steel, Iron, Copper, Silver, &c. when exposed to the same Degrees of Heat, as nearly as I could determine; conceiving it would not be very difficult, by making use of two Sorts of Metals, differing considerably in their Degrees of Expansion and Contraction, to remedy in great measure, the Irregularities to which common Pendulums are subject." Graham finally saw that he had no prospect of success in finding a suitable combination of two metals. However, in December, 1721, experimenting with some quicksilver for a level, he observed the extraordinary degree of expansion of that metal when near a fire, and this suggested to him its use in a pendulum. By comparison of quicksilver pendulums with others in two different clocks he finally obtained a nearly correct length of the column of mercury, on June 9, 1722. As a test he then used the clock in observing star transits from June 9, 1722, to October 14, 1725.

"The Reason, why this kind of Pendulum is more exact than the common Sort, will be evident to any one, who considers, that as Heat lengthens the Rod of the Pendulum, at the same Time it increases the length of the Pillar of Quicksilver, and its Center of Gravity is moved upwards: And when, by Cold, the Rod of the Pendulum is shortened, the Pillar of Quicksilver is likewise shortened, and its Center of Gravity carried downwards; by this Means, if the Column of Quicksilver be of proper Length, the Distance, between the Point of Suspension and the

Center of Oscillation of the Pendulum, will be always nearly the same, upon which the exact motion of a clock principally depends . . ."

Graham concluded that the specific gravity of mercury made it the proper material for the weight of a pendulum, but he never gave up his attempts to make a pendulum of two solid metals, although he never succeeded. At the same time he generously helped and encouraged John Harrison, who about 1726 invented the gridiron pendulum, and Milham suggests that the honor of this invention should go to Graham instead of to Harrison.

On June 4, 1752, the year after Graham's death, John Ellicott, F.R.S., read a paper at the Royal Society, giving a description of two methods of preventing irregularities of a clock due to the effects of heat and cold upon the pendulum. After this, Mr. James Short presented a paper giving an historical account of the contrivances in the pendulum of a clock to prevent these inequalities in its motion, showing Graham to be the first inventor of such a contrivance. Mr. Short's paper started a lengthy discussion between Mr. Sparke and Short which throws considerable light upon the early use and importance of Graham's mercurial pendulum. When at one point in the discussion the question of Graham's character arose, both men, although in violent opposition against each other, agreed on Graham's uprightness and worthiness, as we see from the following excerpt:

"Mr. Short cannot shew that Sparke has said anything tending to reflect on the memory or character of Mr. Graham; he hopes the direct contrary appears in his *Remarks* very visibly."

Aside from their historical interest, the papers by Sparke and Short are but one more evidence of Graham's true scientific spirit, from which arose the high repute in which he was held both in England and outside. This opinion is supported by Britten who writes: "Securing to himself the monopoly of any of his discoveries was foreign to his disposition. The reputation which English horology acquired on the Continent during the eighteenth century was due in no small measure to Graham's candid treatment of his brethren in the art in other countries."

Graham has been called the "first general mechanician of his day," and was everywhere highly lauded for his great skill. His astronomical knowledge was such as to enable him to make not only astronomical clocks and to experiment with the length of the pendulum but also to devise many valuable astronomical instruments, to be discussed later in this paper.

The Gentleman's Magazine for 1751 praises his mechanical and astronomical skill in words later incorporated in Hutchinson's *History of Cumberland County*: "That Mr. Graham was, without competition, the most eminent of his profession, is but a small part of his character; he was the best mechanician of his time, and had a compleat knowledge of practical astronomy; so that he not only gave to various movements for the mensuration of time a degree of perfection which had never before been attained, but he invented several astronomical instruments by which

considerable advances have been made in that science; he made great improvements in those which had before been in use, and by a wonderful dexterity, constructed them with greater precision and accuracy than any other person in the world."

James Bradley, at one time Astronomer Royal and Savilian Professor of Astronomy at Oxford, the discoverer of aberration and nutation, continually lauded Graham and prized him as a friend and assistant. In the 38th volume of the *Philosophical Transactions* appeared an article entitled *"An Account of Some Observations made in* London *by Mr.* George Graham, *F.R.S. and at* Black River *in* Jamaica, by Colin Campbell, *Esq. F.R.S. concerning the* Going of a Clock; in order to determine the Difference between the Lengths of Isochronal Pendulums in those Places, Communicated by J. Bradley, M.A. Astr. Prof. Savill, Oxon. F.R.S." Discussing the instruments in the observatory at Black River, he writes: "Among these is a clock whose pendulum vibrates seconds made by our ingenious member Mr. George Graham, justly esteemed for his great skill in mechanics, who judging that an opportunity was now offered of trying what is the true difference between the lengths of isochronal pendulum at London and Jamaica, readily embraced it, and in framing the parts of the clock, carefully contrived that its pendulum might at pleasure be reduced to the same length whenever there should be occasion to remove the clock from one place and set it up in another." A description of Graham's pendulum experiment follows in full, but this paper will quote the shorter description furnished by Rigaud.

"In 1734 Bradley communicated a paper to the Royal Society on the vibrations of the pendulum in different latitudes and on the figure of the earth which might be deduced from them:

"Colin Campbell, F.R.S. a gentleman who had been brought up under the care of his cousin Archibald, Earl of Isla (who was afterwards Duke of Argyle), established an observatory at Black River in Jamaica. He furnished it with a valuable set of instruments, among which he had a transit, and an excellent mural arch of four feet radius made by Sisson. He employed Graham to make an astronomical clock for him, the rates of which were the foundation of the dissertation in question. The precise length of the pendulum swinging seconds, was a subject in which Graham through the whole of his life took very great interest. Bradley likewise had paid particular attention to it and probably had his share in suggesting and arranging what Graham in a letter to him on the subject calls 'our experiment.' The method which they adopted was to ascertain the number of vibrations made by a pendulum which was unvaried by anything but the difference of temperature, at the two stations where it was made to swing. Graham's own account of his previous observations and experiments . . . is extant, and a memorandum is written on it and signed by Bradley, stating that it was delivered to him on the 9th of September 1731. The contents of . . . (Bradley's paper) . . . are accurately detailed in it, from which it will be seen

that the number of vibrations made in twenty-four hours was reckoned by ascertaining the rate of the clock from the transits of α Aquilae. The contrivance by which 'its pendulum might be reduced to the same length whenever there should be occasion to remove the clock' is stated in the Ms. 'The nut of the pendulum' Graham says, 'which raises or lowers the bob is divided into twenty-six equal parts, one of which corresponds to one second a day. When the clock was observed by the star, the index at the lower end of the pendulum pointed to the fifth division upon the nut, and there was a piece of brass filed of an exact length to reach from the highest edge of the bob to the upper edge of the piece of brass that goes through the bob, to determine at what turn of the screw the nut stood, and the fifth division of the nut determines the part of the turn. This piece of brass was sent with the clock and, lest any mistake should arise in applying the piece of brass, I cut a piece of wood into the form of this part of the pendulum and tied on the piece of brass with some packthread to shew in what manner it was to be applied to the pendulum. Was the nut to be one turn too high or too low, the piece of brass would reach above or fall short of the edge before mentioned by the space that is between one thread of one screw and the next, which is too great a quantity to be overlooked or not readily perceived'."

This experiment testifies to Graham's all-around fund of knowledge, his experience as a professional clock-maker, his general mechanical skill and his practical astronomical training. It also shows his interest in the contemporary scientific problems, such as the form of the earth. Graham was also in communication with the French Academy of Sciences on the subject of the length of the pendulum, for in the annals of that body for 1735, we find an article on the length of the simple pendulum which beats seconds of time, giving Graham's measurement of the length of such a pendulum at London. Graham also made instruments for Bradley, who was carrying on experiments in the same field.

Besides the above mentioned astronomical clock for the Black River Observatory, Graham made others, including one for the observatory at Upsal. He also added a gridiron pendulum to a Greenwich Observatory clock used by Bradley for recording the times of transit observations. This may possibly be the clock referred to by Maskelyne, fifth Astronomer Royal, when he states that there was added to the Observatory equipment in 1750, "an excellent astronomical clock with a gridiron pendulum, made by Mr. *John Shelton* under the direction of Mr. *Graham* and fixed up in the transit-room by which the transits of the heavenly bodies over the meridian are observed . . . "

That a connection exists between making clocks and making astronomical instruments is quite obvious. In fact, the members of the Clockmakers' Company were for many years makers of mathematical instruments as well. Mathematical and astronomical instruments are dependable or not in accordance with the accuracy of the proportioning of their parts and the division of their scales. But the closest contact between clocks and astronomical instruments is due to the basic meas-

urement of time itself.

Sidereal time is measured by a sidereal clock regulated by star observations. Though the pendulum of the sidereal clock is shorter and quicker-moving than the pendulum of a mean time clock, the principle of construction is similar. Thus, in making sidereal clocks, George Graham took only a short step from the making of ordinary clocks, but by this step he bridged the gap to the construction of astronomical instruments. Although no reference to astronomical clocks by Graham was found other than those already quoted, it is probable that his interest in astronomical instruments is due to the close alliance between the two kinds of clocks. It is also quite evident that his interest in astronomy was real and deep, and productive of important results. He was especially noted for the perfection with which he graduated his circles. He made the division of 96 on the limb as well as that of 90°. These 96 divisions were equal and subdivided into 16 parts, making continual bisection possible.

The Royal Observatory at Greenwich was the center of astronomical interest during the eighteenth century. Graham's active connection with it began after the death of Flamsteed, the first Astronomer Royal, in 1719, and under the direction of his immediate successor, Halley. In 1725 he made a valuable 8-foot quadrant for the Observatory. Halley, for the purpose of correcting the coefficients of the lunar equations, needed to obtain the right ascensions of the moon and nearby stars. Unfortunately, the meridian telescope, installed at Greenwich by Flamsteed, gave him only one coördinate of our satellite, and Graham constructed this new instrument in order to obtain both coördinates by one observation. It was placed in the position formerly occupied by Flamsteed's quadrant, and on a pile of stone which replaced the brick wall formerly at that place. Made out of forged iron, it showed every 13 seconds of arc by means of a vernier. The reticule was composed of only two crossed wires, one horizontal, the other vertical. Halley used the instrument until the time of his death to determine simultaneously the two coördinates, right ascension and declination, of the moon, the planets, and the zodiacal stars. The idea of using the same instrument for the complete observation of a star was dropped at the end of the eighteenth century, but was taken up again in the second half of the nineteenth. The instruments of Halley and Flamsteed, modified and perfected, are what we call *meridian circles*. The *Gentleman's Magazine* for 1751, in the article already quoted, speaks of this "great mural arch in the observatory at Greenwich," saying that it was made under Graham's "immediate inspection and divided by his own hand; and of this incomparable original, the best instruments of the kind in France, Spain, Italy, and the West Indies, are copies, made by English artists." In 1753 Graham's quadrant was removed from its place and a new set of divisions added to it by Bird.

This mural arch is well known, but its fame can scarcely compare with that of the sector by which Mr. Bradley discovered two new mo-

tions in the fixed stars. This sector, which was still in use at Greenwich in the nineteenth century, has an arc of 12°. It was attached to an axis parallel to that of the earth, turning on it in the direction of diurnal motion. The advantage of the instrument lay in the length of the radius of the arc and the focal length of the telescope.

Samuel Molyneux, a rich man and an amateur in astronomy, was a close friend of Bradley, and the two carried on many observations together. In fact much of Bradley's valuable work was done at Molyneux's observatory at Kew, in Surrey, with instruments constructed by Graham.

A new train of thought had been started in their minds by Picard's observations of the annual inequality of the motion of the pole star. "With the aim of verifying all that had been said on that subject, Molyneux had Graham make him a sector with a radius of 24 feet and an angle of about 15 minutes of arc, which he installed in his observatory, and with which he proposed to study the star γ Draconis; which being but a few minutes from the zenith was not subject to errors due to refraction." Molyneux's instrument was for studying the annual parallax of the fixed stars, but Bradley, continuing Molyneux's observations, found the sector inconvenient because of its size and had another constructed with one-half the radius and with an angle of 12° 30′ in order to follow variations of stars farther from the zenith. "The instrument was contrived and completed under the direction of Graham, who must have divided the arc, and probably himself executed or finished all those parts which required a nicer construction than the rest . . . " Bradley had it erected at Wansted and made with it those observations which resulted in the discovery of aberration. From Rigaud's *Bradley Memoirs* we pick out the following quotation concerning the instrument in question: "In 1725, he (Molyneux) was living at Kew, and Graham made him an instrument for this especial purpose. Bradley mentions it as 'constructed almost upon the same principle' as Hooke's. There was however a strong distinction between them, for Hooke's, as we have seen, had no tube, and the axis of it was intended to be directed to the zenith; whereas Graham's plan was to direct the axis of his instrument constantly to the star, so that the deviations might be determined by the angles through which it might be necessary for the telescope at different times to be moved. For this purpose the glasses were fixed in a tube made of strong firm tin plate, very carefully and closely soldered together, which moved on an horizontal axis on the top of it. The whole was supported by some iron work, which was fixed very strongly to a large stack of brick chimneys, which were quite within the house, and scarce at all exposed to the weather, and were very strong old built chimneys, some part of the house being near three hundred years old. On the north side was fixed a small brass skrew which—touched with its point, which was directed southward,—the lower end of the tube—and the telescope was gently pressed against the point of the skrew, being drawn by a string passing over a pulley, with a small weight at the

lower end of it." Still further details concerning the instrument and the way it was set up are given.

Both Molyneux and Graham took a personal interest in Bradley's work, and we read the following in one of the latter's papers: "Mr. Molyneux and Mr. Graham came to Wansted, and we fixed up the brass work and tube, &c. of the parallactic instrument, the iron work having been finished the week before."

When Bradley became Astronomer Royal at the death of Halley in 1742, his first move at Greenwich was to attend to the repair of his instruments. In this enterprise Graham was of great help, doing everything that was necessary to his own quadrant. Shortly after his death, Bird, a skilled and well-known instrument maker, did some work for the Observatory. He began by making himself fully acquainted with the general construction of the old quadrant, and found its plan to be such as to afford a lasting testimony of Graham's skill in mechanics.

Graham's reputation as an astronomical instrument maker was great. He did not confine himself to quadrants and sectors, but made smaller instruments too. For example, we know that he made levels, because it was while experimenting with them that he noticed the great expansion of mercury when exposed to heat. This was the germ of the mercurial pendulum on which so much of his fame as a clockmaker rests. He also seems to have made portable telescopes.

"The first Planetarium made in England was the work of his genius; it was made for *Lord Orrery,* whose name has ever since been given in this country to all machines of this description." This instrument, made for Charles Boyle, 4th Earl of Orrery, showed with great accuracy the motion of the celestial bodies.

Even in France the name of George Graham was well known and honored. From the same article in the *Gentleman's Magazine* so often quoted, we have this: "and when the French academicians were sent to the north to make observations in order to ascertain the figure of the earth, they thought Mr. Graham the fittest person in Europe to furnish them with instruments; they accordingly succeeded, performing their work in one year, so that by a subsequent observation in France, Sir Isaac Newton's theory was confirmed.—But the academicians who went to the South, not taking Mr. Graham's instruments, were very much embarrassed and retarded.—" The zenith sector used by this expedition, in measuring the length of a degree of the meridian at a high latitude (Torneo: 65° 50′ 50″) was his fabrication and "resembled that used by Bradley in the observations which established the aberration of light." However, his previous experience had enabled him to make an improvement in the new instrument. In the construction of the Kew sector "the plumb-line had been made to hang from a small notch in the center of the horizontal axis—and when Graham made the sector for the measurement of the arc in Lapland he adopted a different method of suspension . . . " As described by Todhunter:

"The instrument used for determining this difference of zenith-

distance was a zenith-sector made by Graham at London; the instrument resembled that used by Bradley in the observations which established the aberration of light. A copper telescope-tube nine feet long formed one radius of the sector; the extent of the arc of the sector was 5½° graduated at every 7½′. At the focus of the telescope were fixed two wires at right angles. The telescope and the arc formed one instrument. A large pyramid of wood 12 feet high served as the support of the instrument. The instrument could turn freely round a horizontal axis; it was moved by a micrometer screw acting in opposition to a weight. A plumb-line was suspended from the center of motion, and marked on the graduated arc the angle through which the instrument had been turned. The absolute zenith-distance of a star at a given place was not determined by the French observers, but only the *difference* of zenith-distance at two given places."

The later years of Graham's life were almost exclusively devoted to astronomical pursuits, even to the detriment of his horological work. As Britten suggests "his mind was taken up with astronomy and astronomical instruments, and the production of a perfect clock as an aid to the astronomer absorbed him, . . . almost to the exclusion of horological instruments for the pocket."

Graham stands out in the history of instrument making, but he is not alone. Comparable to him are Abraham Sharp, who divided Flamsteed's great quadrant, and Bird, who brought greater perfection to the art of graduating circles.

In discussing the making of astronomical instruments, we have stressed the importance of mechanical skill. However, a knowledge of practical astronomy is almost equally necessary, and can be obtained only by actually working with the type of instruments one expects to construct or improve. Graham would probably have ranked as an astronomer had not his work in other fields overshadowed his achievements in actual observation. However, many of his own observations, together with those of other members of the Royal Society which were made at his house in Fleet Street with his instruments, are recorded in the Society's *Philosophical Transactions.*

As early as November 27, 1722 (PM. Greenwich) Graham observed a solar eclipse, which, as reported in the *Philosophical Transactions,* was observed at the Greenwich Observatory by Edmund Halley, then Astronomer Royal and Savilian Professor of Geometry at Oxford. Halley's report is in Latin and consists of complete observations numerically given and a notice to the effect that the weather was quiet throughout. Graham's observation made in Fleet Street was also completely reported. However, his description of the circumstances which accompanied the phenomena was so much more detailed than Halley's, that its precision and care are worthy of particular notice. It is given here: "I Had very correct Observations both of the Sun and Stars, the 26, 27 and 28th, for determining the exact Time by my Clock.

"For some Minutes before the Eclipse began, I observ'd the Sun with

a Telescope of 12 Foot, furnished with a Micrometer; keeping that Part of the Limb in the middle of the Glass, where I expected the Moon first to touch, and in less than four Seconds of Time, from the Moment I judged the Eclipse begun, it was so considerably advanc'd that I cannot doubt of having the Beginning to less than three Seconds. I believe the exact Time of ending was within the same Limit, notwithstanding that the Undulation of the Limb was then much greater than at the Beginning. The Parts eclipsed, measured with the Micrometer, at the Time of the greatest Obscuration, were 927 such Parts as the Sun's Vertical Diameter contained 1946; which was taken a little before the Beginning of the Eclipse.

"The Sky was clear, and free from Clouds, till near the End, when a narrow one obscured some part of the Sun's Disk, but that part of the Limb where the Eclipse ended, continued clear until after it was over.

"By this Observation the Beginning differed not 2½′ and the End not ½ a Minute from Dr. *Halley's* Computation, which he sent me the Day before. And if this Computation, which was made for *Greenwich*, had been reduced to the Meridian of *London*, the Difference would have been still less."

Graham assisted Bradley in the observation of the comet of 1723, which work attracted the attention of the Right Honorable the Lord of Paisley, F.R.S., who wrote to him enclosing "some curious Figures of the same Comet."

In 1725-6 Graham assisted Bradley at Kew, and during 1732 and 1733 reported a lunar and a solar eclipse which he observed in Fleet Street. He reported another lunar eclipse as taking place on March 15, 1735-6. This double year date requires explanation. The year was at one time assumed to begin on March 25, and this system was observed in many countries for several centuries even after the year was generally reckoned from January first. In England the older method was for a time called the legal year and was in use up to 1751 A.D. when the Julian form of year counting from January first was everywhere installed. This eclipse, taking place on March 15, would have been dated as belonging to the year 1735 by the older method, but to 1736 in the Julian system. This explanation seems all the more plausible when we consider that Oppolzer "Canon der Finsternisse" records no lunar eclipse for that time in 1735 but gives one for March 14, 1736, Julian calendar, which seems to be the same as Graham's. Also, on other occasions whenever a double year date appeared for observations made before 1751, the phenomena occurred between January 1st and March 25th. When Graham was making magnetic observations, he describes no experiment between March 20, 1722, and March 29, 1723. Since there is no reason to believe he discontinued his observations for a period of a year, without making a special note of it, it is more reasonable to suppose that during the nine days between his two recorded observations the year date changed from 1722 to 1723.

In 1736 Graham observed a lunar eclipse, an occultation of Mars by

the Moon, and a transit of Mercury over the Sun. A solar eclipse was recorded with the double year date February 18, 1737-8. In 1738 Graham also reported observations on a solar eclipse and an occultation of Aldebaran by the Moon. A good many observations were made by his friends from his house in Fleet Street, especially after 1740, when, no doubt, he himself was getting too old to observe.

Besides his astronomical interests, Graham was attracted by research work on barometric and magnetic phenomena, and communicated several papers on these subjects to the Royal Society. He was the first to measure the magnetic intensity by the vibrations of a needle and also the first to observe the diurnal variations of the needle.

In 1721, he reported the extraordinary height of the barometer which reached more than 30.8½ inches.

George Graham was often called upon to render public services as adviser to the Royal Observatory on the purchase of new instruments, and as the authority for the Royal Society on standards of measurement.

It is evident that he contributed greatly to the progress of practical astronomy, and it is most doubtful whether or not his contemporaries could have attained the same success had they not been furnished with the excellent instruments of his fabrication.

The twentieth century can add no significant tributes to those already expressed by his contemporaries.

Bradley, in a communication to the Royal Society, called his friend "our curious member, Mr. George Graham" and six years after the latter's death referred to him as "the late ingenious Mr. George Graham." He not only clothed his appreciation of Graham in beautiful phrases, but concretely acknowledged the debt he owed him:

"for I am sensible" he wrote "that, if my own endeavors have in any respect been effectual to the advancement of astronomy, it has principally been owing to the advice and assistance given me by our worthy member Mr. George Graham; whose great skill and judgment in mechanics, joined with a complete and practical knowledge of the uses of astronomical instruments, enable him to contrive and execute them in the most perfect manner."

No greater tribute than this could be paid to George Graham.

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VASSAR COLLEGE OBSERVATORY, JUNE, 1930.

THE THIRTEEN MONTH CALENDAR

By JOHN A. INGHAM.

The present agitation for a thirteen month calendar, each month to contain exactly four weeks and every month to begin with Sunday, is commonly traced to Mr. Moses B. Cotsworth, who was connected with the Northeastern Railway in England as far back as 1888. Finding, as statisticians and accountants always do, difficulties in making accurate comparisons of monthly statements, he suggested the division of the year into thirteen months of 28 days each, and proposed to make each month begin with Sunday by omitting from the reckoning one day in each year, to be called possibly "Year Day," following Saturday, December 28, and preceding Sunday, January 1. Year Day would not be counted as a day of the week or of the month. In leap years another such day would be added in summer. The proposal carries also a suggestion for fixing the date of Easter. That phase of the subject is treated below.

A report of the National Committee on Calendar Simplification (343 State Street, Rochester, New York) states that the "first known proposal to use blank days to establish a fixed and perpetual calendar" was in a book published at Rome in 1835 by l'Abbe Marc Mastrofini. The French philosopher, August Comte, mentioned a similar plan in one of his works (1849). The plan received no practical consideration until published by Mr. Cotsworth early in the present century. Following that a bill for calendar reform was introduced in the British Parliament in 1908. In 1910 the Congress of European Chambers of Commerce recommended an International Convention to consider the subject. In 1918 a bill was introduced in the House of Representatives by Representative J. M. C. Smith (H.R. 11486, 65th Congress, 2nd Session). In 1923 the League of Nations appointed a Committee of Inquiry on Calendar Simplification, by whom opinions and comments have been gathered from a number of governments, as also (concerned particularly with the date of Easter) from the Holy See.

The United States did not officially appoint a committee to coöperate with the Commission of the League of Nations, but such a committee has been constituted voluntarily with Mr. George Eastman of Roches-

ter as Chairman. This Committee has been active in urging the change. The proposal was made that the change should be launched in 1933, as that year begins with Sunday. It seems fair to say that no such change is now feasible at so early a date. The time has become too short for the necessary adjustments, and it is far from clear that the nations are ready to agree to the plan proposed. It is expected that the whole question will come before the next General Conference on Communications and Transit, to be held under the auspices of the League of Nations in 1931.

The arguments urged for the change are that it would do away with months of varying length, such as we now have consisting of 28, 29, 30, and 31 days. It would avoid "split weeks," that is weeks which are partly in one month and partly in another. It would put an end to wandering holidays. It would obviate the need for new calendars every year. A single calendar covering 28 days would serve perpetually. (Of course the moon's phases would have to be indicated in some supplementary way for those interested.) Possibly the greatest advantage claimed for the fixed calendar would be the more accurate comparison of monthly statements. These would be as nearly comparable as it is possible to make them.

On the other side it is urged that tradition and habit, reaching back to the time of Julius Caesar (as shown below) and covering the whole Christian era, are very strong and very significant. There would necessarily be no little confusion of dates, appointments, and anniversaries incident to the time of transition. An agreement of all nations will be hard to secure. This will postpone decisive action for some years at the very least. There is also a somewhat formidable religious objection. The proposed change involves one week of eight days in every year, and two such weeks in leap years. The Honorable Sol Bloom, representing the 19th New York district in Congress, voices this objection in the phrase, "The Wandering Sabbath." As yet religious opposition is mainly from those who observe Saturday as their holy day, but it seems probable that many members of the Sunday observing groups will be found opposing the change, once it is clearly understood. It must be remembered that relatively slight matters of detail have sufficed to start religious controversy in days gone by. One fears that the adoption of the blank day principle would start a new line of cleavage in some religious bodies, separating those who would insist on the regular observance of each seventh day as a holy day from those who were not disturbed over the annual insertion of one or two days not to be counted.

Mr. Bloom's speech in Congress, June 11, 1929, giving his objections to the change, may probably be secured from him on request. The League for Safeguarding the Fixity of the Sabbath, 40 West 32nd Street, New York City, publishes literature opposing the change. There is also a periodical called "Liberty" published at Takoma Park, Washington, D. C. Literature favoring the change is issued by the National Committee on Calendar Simplification, 343 State Street, Rochester,

New York, as well as by the International Fixed Calendar League, 1901 Wyoming Avenue, N. W., Washington, D. C.

For our purpose at present the history of the present calendar is relatively simple, as it involves only two outstanding changes. Julius Caesar in the first century, B.C., ordered the abandonment of the effort to observe lunar months. Pope Gregory XIII, late in the 16th century, directed the omission of ten days from the monthly count to bring the vernal equinox forward to March 21, and made provision for greater accuracy in the future.

Before Caesar's time the calendar was lunar, as it is with most primitive peoples. Life's ordinary routine in nomadic and pastoral conditions is largely affected by the moon's changes. Meton, as far back as 432 B.C., is credited with the invention of the cycle that bears his name. He noted the approximate equality of 19 solar years and 235 lunar months. But in practice the adjustment was far from clear, and political considerations may have influenced those at Rome who controlled the intercalation of months. At any rate Julius Caesar found that the calendar was some 80 days out of correspondence with seed time and harvest. He cut the Gordian knot by abandoning all effort at lunar months and by lengthening the year 46 B.C. (A.U.C. 708) to 445 days. Then B.C. 45 began the regular observance of the Julian Calendar, which prevailed until the time of Pope Gregory, that is for over 1600 years.

There is a curious story of confusion at the outset through misunderstanding of Caesar's plan. As he was assassinated in March, B.C. 44, he could no longer direct events. In line with the Roman modes of reckoning, those in charge apparently counted each leap year as one of the four preceding the next leap year. Thus in the course of thirty-six years twelve leap years were observed instead of nine. The error was discovered under Augustus and rectified by his order that the next twelve years should all be common years. Then followed the regular succession of leap years until Gregory's time.

Julius Caesar's calendar had the mark of genius in its extreme simplicity. It is well known, however, that it was slightly in error, making the year about 11 minutes 14 seconds too long. By the time of Pope Gregory XIII the accumulated error had brought the vernal equinox back to March 11. Gregory directed that thereafter three leap years should be omitted in each four centuries, that is 1700, 1800, 1900, 2100, 2200, 2300, 2500, etc., should all be common years, while 1600, 2000, 2400, etc., should be leap years. He also desired to bring the vernal equinox to the date of its occurrence in 325 A.D., the year of the Council of Nicaea. So he decreed that the day after Thursday, October 4, 1582, should be Friday, October 15. That was done in a number of countries. France made the change in December, 1582, calling the day after Thursday, December 9, Friday, December 20.

Religious feeling ran high in the 16th century, and England and her colonies refused to follow the lead of the Pope. It was not until 1752 that the change was made by act of Parliament, the day after Wednes-

day, September 2, being called Thursday, September 14, dropping eleven days because the year 1700 had widened the breach between the Julian and the Gregorian Calendars by one more day. It is a curious fact that the Gregorian Calendar was in use, to some extent at least, on Manhattan Island under the Dutch rule, prior to 1664. With the incoming of the English, the Julian Calendar again became official, and so continued until 1752.

Japan adopted the Gregorian Calendar in 1873. China took steps in the same direction in 1912, but old habits are tenacious. Apparently the Chinese New Year festivities are deeply rooted in the affections of the people. A dispatch from Shanghai under date of January 1, 1930, stated that documents framed according to the lunar calendar would no longer be recognized as legal. Turkey, Russia, Rumania, Serbia, and Greece adopted the Gregorian Calendar in the years 1917 to 1923, though the Soviet Government is said to be following an entirely different calendar now.

Reference is made above to fixing the date of Easter. This is not dependent upon the adoption of a new calendar. It has been proposed to fix it within a limit of seven days by making Easter the Sunday after the second Saturday of April, that is confining it to the limits April 9 to 15 inclusive. One reason for this particular proposal is to avoid the coincidence of Passion Sunday (two weeks before Easter) and the Annunciation (March 25). This change could be made at any time, if all Christian bodies should agree to it. The British Parliament has taken steps in that direction. The attitude of the Holy See is reflected in its reply to the inquiry from the League of Nations Commission, stating that there are no objections from the point of view of dogma, but the change would involve the abandonment of deeply rooted traditions from which it would be neither legitimate nor desirable to depart except for weighty reasons of universal interest.

It was certainly a stroke of genius when Julius Caesar put an end to the confusions of the former lunar calendar by his extremely simple plan. One does not wonder that the plan was followed for 1600 years. Indeed it is still followed with the relatively slight modification which Gregory introduced. The rule by which Easter is ascertained has also persisted for many centuries, though it is anything but simple. There were controversies over the date of Easter in the early centuries of the Christian era. The Council of Nicaea, 325 A.D., devised a plan for settling these controversies and fixing a date for Easter which should bring it near the full moon, always on a Sunday, and not on the day of the Jewish Passover. The last objective was not completely achieved, though the coincidence is rare.

The Nicene rule was that Easter should fall on the Sunday next after the full moon that occurred next after the vernal equinox; and when the full moon fell on Sunday Easter should be the next Sunday. Also the vernal equinox was to be taken as occurring on the 21st of March, and the full moon was to be determined by tables prepared for the pur-

pose. The Metonic Cycle of 19 years was taken as a guide and tables were prepared showing the expected occurrence of full moon for the whole nineteen years, after which the table would repeat. The number of the year in this 19 year period is its Golden Number. As now computed the Golden Number is one more than the remainder obtained by dividing the year number by 19. Thus 1930 has 12 as its Golden Number, 1931 has 13 and so on. The table of Paschal Full Moons for the different Golden Numbers is given in the World Almanac (1929, p. 50; 1930 and 1931, p. 66). Thus Golden Number 12 gives April 13, and 13 gives April 2. As April 13, 1930, was Sunday, Easter was observed April 20. As April 2, 1931, will be Thursday, Easter will be the following Sunday, April 5.

The Dominical Letter is used to find the day of the week for any given date. These are the letters marking Sundays, if one starts with January 1 and marks that A, January 2, B, and so on to G (January 7). January 8 will be A again, as also January 15, 22, and 29. January 31 will be C, February 1 will be D. The following sentence is an aid to memory, giving the letter for the beginning of each month:

At Dover Dwell George Brown Esquire, Good Christopher Finch
Jan. Feb. March April May June July August Sept.
and David Friar
Oct. Nov. Dec.

In leap year there are two Dominical Letters, one for January and February, the other for the rest of the year. As an ordinary year contains one day more than 52 weeks, the Dominical Letter slips back one place, two places in leap year. The Dominical Letters for the years just before and behind us are:

1928 A G
1929 F
1930 E
1931 D
1932 C B
1933 A
1934 G and so on.

Thus it is seen that in 1930 June was the only month beginning on Sunday (and therefore the only month with the 13th on Friday). In 1931 February, March, and November will begin on Sunday. In 1932 May will be the only month beginning on Sunday.

Another ingenious method for reaching much the same result, provided some one day is known as a starting point, is this: The last day of February (whether 28th or 29th) is the same day of the week as the fourth day of the fourth month, the sixth day of the sixth month, the eighth day of the eighth month, the tenth day of the tenth month, and the twelfth day of the twelfth month.

Karl Friedrich Gauss devised a formula, however, for finding Easter directly by computation. In its full form it is somewhat intricate. It may be found in the Century Dictionary and Cyclopedia, Vol. III, p. 1823, s.v. Easter. As applicable to our own time it may be stated more simply thus:

1. Divide the number of the year by 19; call the remainder A.
2. Divide the number of the year by 4; call the remainder B.
3. Divide the number of the year by 7; call the remainder C.
4. Divide $19A + 24$ by 30; call the remainder D.
5. Divide $2B + 4C + 6D + 5$ by 7; call the remainder E.

Easter will be $22 + D + E$ of March; or if this is more than 31, then $D + E - 9$ of April.

This rule is for the 20th and 21st centuries. For other centuries the constants, 24 and 5, above are to be changed. There is also this exception: If the rule gives April 26, the true date is April 19. If the rule gives April 25, and if D is 28 and A is more than 10, then the true date is April 18. (This last exception applies to 1954.)

AMERICAN ASTRONOMICAL SOCIETY

REPORTS OF OBSERVATORIES 1929-1930

(Continued from page 145.)

LOWELL OBSERVATORY

FLAGSTAFF, ARIZONA

Last year's report gave a brief description of the new 13-inch photographic telescope which had been planned especially for continuing the search for Lowell's predicted trans-Neptunian planet, and stated that the search had been resumed under promising conditions.

Mr. Tombaugh was carrying on the systematized search and on February 18, when comparing plates made January 23 and January 29, he came upon an object that had shifted between the two dates by about the amount to be expected of a trans-Neptunian body. A third available plate, secured January 21, also showed the object. The plates were consistent in indicating the object to be very distant. The images were clearly real and obviously the record of a very distant solar system body. But, obviously, they could not in themselves be considered sufficient to decide whether or not they were the record of Lowell's long-sought "Planet X."

The one question then was: Would the next plate find it in the expected place? It did! As soon as possible the object was examined with the large refractor. We were disappointed to find it did not show a planetary disk, although we realized its faintness would make this observation difficult. A definite decision as to the real nature of the object must therefore be reached through further observations. For a time Mr. Tombaugh followed it with the photographic telescope, Astronomer Lampland carried on his long series of photographs of it with the large reflector for measurements of daily rates of motion for preliminary estimates of its distance and to see what such plates might show, and in

particular to get a full series of accurate positions to be utilized in finding its orbit. Astronomer E. C. Slipher and the writer continued to observe it carefully with the large refractor, utilizing the best observing conditions to see if any evidence of disk might be detected, to judge of its color and brightness, and to find any distinctive features it might possess. No certain evidence of disk could be made out, although on a few occasions its image seemed not quite like those of equally faint stars. At no time did it show the least indication of any cometary features. Its color was inferred to be yellow because it was seen to be brighter visually than photographically, compared with stars. Instead of attempting its spectrum, color filter plates of it and of Neptune were made with the reflector and these too indicated that it was yellowish—not bluish like Neptune. The reflector plates of both long and short exposures showed for it only a typical starlike image.

Meanwhile it was observed night after night to keep to its expected path among the stars, its motion decreasing in accord with its approach to its stationary point. The rate of its drift was obviously the index to its distance. And from the beginning its shift was frequently translated into distance and always showed the object to be clearly trans-Neptunian. From measures of the reflector plates Astronomer Lampland got a close approximation of the distance as being between 40 and 42 astronomical units. He derived positions from these plates and for earlier ones of 1915 and 1929 and gave a paper on this work at the recent New Haven meeting of the American Astronomical Society.

The preliminary orbit was computed with the supervision of Dr. John A. Miller, director of the Sproul Observatory, as published in the *Lowell Observatory Observation Circular*. Unfortunately a slight dissymmetry of the image on the small-scale record plate of January 23 affected its position enough in the extremely short arc available for computation to produce in the resulting orbit a greatly exaggerated eccentricity, size, and period, elements emphasized as uncertain in announcement.

The yellow appearance of the new planet showed it to differ from the blue planets Neptune and Uranus, planets with high albedos and low densities, and suggested that in albedo and density as well as color it might be like the inner planets. Mars at the distance of Pluto would be at least as faint as is Pluto. Experience in observations of small and faint satellite disks indicated the new planet's disk might be as large as half a second of arc and not be discernible because of the planet's faintness even if there be present no fading toward its limb. Later tests, with the same telescope, of a distant target of graduated apertures, which was subjected to wide variation in its illumination, indicated that with Pluto's faintness his disk, if as much as six-tenths of a second of arc, could escape detection under good observing conditions. Hence if Pluto has a Mercury-like albedo he could have a globe and a mass equal to or a little larger than the Earth's and show no disk under the conditions of observation.

Planetary observations have been continued both visually and photographically as heretofore by Astronomer E. C. Slipher using the 24-inch refractor. The quarter-century-old series of yellow-light photographs was continued with the same kind of plate and filter in order to keep this annual record homogeneous and comparable. Other plates and filters of various spectral ranges were used as in past years for red, yellow, blue, and ultra-violet photographs for special studies. Most attention was given to Jupiter and Saturn, some to Venus and Mercury, while Mars, being near superior conjunction, was not observed.

Jupiter, under observation from September, 1929, to March, 1930, proved relatively quiescent compared to last year's period of tremendous activity and the belts showed the more normal form, distribution, and color as in early 1926 before the advent of changes which culminated in the great transformations of 1928. Most instructive in the general problem of interpreting differences which arise between color-filter photographs of the planets were the red, yellow, and violet photographs of the Great Red Spot this year. After nearly three years of being predominantly dark in blue-violet photographs but scarcely visible in red and yellow ones because of its reddish color, the Red Spot again became practically isochromatic this year, showing alike in red, yellow, and blue light photographs, as expected from its neutral tint. In this and other features the various photographs corroborated the explanation offered here before to account for the differences occurring in contemporaneous photographs in different colors, to wit, that the relative color values of the markings, coöperating with the plate emulsions, are the important factors involved in producing differences in the relative luminosities in monochromatic photographs of the planet, and not the altering effect of his atmosphere.

Saturn showed a marked change from its aspect in 1927 and 1928. Especially noteworthy was this transformation because the ball, which had been unusually reddish, became nearly isochromatic, showing about the same range of luminosities in violet as in red and yellow light photographs. The broad, dark sash across the equator in the blue and violet photographs from 1926 to 1929 was absent in 1930, in fact it became the brightest band on the ball, appearing very much as it has always appeared visually and in the yellow-light photographs. The complete reversal in luminosity of this band in blue light was doubtless due to the change in color. Obviously the explanation expressed above to account for differences in color-filter photographs of Jupiter appears to apply equally well to Saturn.

These photographic studies of the planets were made, as for several years past, so as to permit photometric measurements and related results. In this connection, numerous experiments were continued with plates and filters in photographing various terrestrial materials and objects to aid in interpreting the planetary results.

Photographs in different colors were made of Jupiter during the past opposition, with the 42-inch reflector, in which only mirrors were used

in the optical system, in order to avoid possible chromatic effects, the enlargement being made with a convex mirror giving an equivalent focal length of 80 feet. In most cases the filters were optically figured glass. Many brands of plates were used in the experiments with careful attention to exposures and development.

On some of the objects on which he has carried on systematic photographic observations over many years Astronomer Lampland has continued these series but only a small number of plates have been made. In observational radiometry only a limited amount of work was done the past year owing to other demands upon his time, a considerable part of which was given to observational work in terrestrial experiments, supplemented by laboratory work. For the last months of the year much of his time was given to the Pluto investigation. Some additional radiometric equipment was completed for obtaining data to supplement the long series of planetary measurements of past years. A small observing house constructed on top of the new dome of the Lawrence Lowell telescope now permits measurements for full diurnal arc, unobstructed by trees and buildings, much needed for some of the measurements on the sun and moon. He has also made some microphotometer tracings of planetary photographs and added to the laboratory equipment apparatus for sensitometry and photometry. Automatic electromagnetic shutters giving a considerable range of exposures with accurately timed intervals that may be recorded on a new chronograph, if desired, have been added to the planetary camera of the 42-inch reflector and to the standard light of the sensitometer. The efficiency of the microphotometer has been increased by the addition of the new rapid ($2/10^8$) Moll quick vacuum thermocouple and Moll Micro galvanometer by Kipp and Zonen.

During the year much time has been given by the members of the staff to bringing their extensive observational material into readiness for publication in the near future.

No new lines of work have been taken up except such as are incidental to the observatory's usual program.

The search of the ecliptic with the efficient 13-inch telescope is being continued by Mr. Tombaugh. A band of considerably greater width is being carried round the sky and the reach in magnitude of stars included has been increased.

There have been no changes in the staff during the year.

V. M. Slipher, *Director.*

OBSERVATORIES OF THE UNIVERSITY OF MICHIGAN

Ann Arbor, Michigan, and Bloemfontein, South Africa

(July 1, 1929-October 15, 1930)

Staff. For the second time within three years, death has taken a director of the Observatory of the University of Michigan and head of the Department of Astronomy. Professor R. H. Curtiss, who succeeded

Professor W. J. Hussey in 1926, passed away on Christmas Day, 1929. Following the death of Professor Curtiss, Dr. W. C. Rufus was made Acting Director until the appointment of Dr. Heber D. Curtis as Director, who took charge on October 15, 1930. The staff at Ann Arbor has included also Assistant Professors D. B. McLaughlin and A. D. Maxwell; Mr. W. J. Williams (succeeded in September, 1930, by Mr. R. M. Petrie); Dr. Hazel M. Losh; Miss Mary E. Lindsey, secretary and seismological assistant; Mr. H. J. Colliau, superintendent of instrument construction; and Mr. Nuel E. Smock, instrument maker. There were also six part-time student assistants.

The staff at Bloemfontein has comprised Associate Professor R. A. Rossiter (in charge) and Messrs. M. K. Jessup and H. F. Donner.

Judge Henry S. Hulbert, Mr. Francis C. McMath, and Mr. Robert R. McMath, Honorary Curators of Astronomical Observations, have been associated with the Ann Arbor staff in several projects and their coöperation has been of great value to the institution. The McMath-Hulbert Observatory at Lake Angelus (near Pontiac) is equipped with a 10-inch reflector with a telechron motor driving clock designed by them and constructed at the Observatory instrument shop. A special movie camera is attached to this telescope with which they are securing results of great interest in the application of the cinematograph principle to celestial photography.

Instruction. In spite of the handicap due to the sickness and death of the head of the department, all the scheduled work of the department has been carried on; the total student enrollment has been 535.

Equipment. The instrumental equipment of the Angell Hall Student Observatory has been increased by the addition of a Howard sidereal clock and a Hale spectrohelioscope. A Moll recording microphotometer from Kipp and Zonen has been received. A Brown & Sharpe No. 13 universal grinder has been added to the instrument shop.

A site for the new observatory which had been approved by Dr. R. H. Curtiss has been secured; it contains about two hundred acres and is situated south of Base Lake. Progress has been made in the survey and preliminary lay-out of this site, as well as in the tentative plans for a large reflecting telescope.

Research. The regular program of observations with the one-prism spectrograph attached to the 37½-inch reflector has been continued; 857 spectrograms were made during the year with this equipment, bringing the total number of plates to about 10,000. Recent work has included chiefly stars of spectral class B with emission lines; also a few stars of class O and selected variable stars. The extensive spectrographic observations of the late Dr. R. H. Curtiss were left in various stages of progress and have suffered irreparable loss.

A program of observation of eclipsing binaries with a Zöllner photometer attached to the 12-inch refractor has been continued by D. B. McLaughlin.

The staff of the Lamont-Hussey Observatory at Bloemfontein, South Africa, has made notable progress in the continued discovery of new double stars with the 27-inch refractor. In spite of the fact that the number of cloudy nights during the year was larger than usual, about 1200 discoveries were made, bringing the total on July 3, 1930, to 2981.

Miscellaneous. 101 seismic disturbances were recorded during the year by the Bosch-Omori and Wiechert seismographs, and were studied and interpreted by Miss Lindsey. Standard morning and evening meteorological observations have been regularly made, as in previous years. 1560 visitors have been received at the University Observatory and at the Angell Hall Observatory during the year.

W. Carl Rufus, *Acting Director.*

MOUNT WILSON OBSERVATORY

Carnegie Institution of Washington

Pasadena, California

Sun-spot activity decreased in 1929 as compared with 1927-1928, although in December there was a marked revival. Spectroheliograms were obtained on 312 days (July 1, 1929, to June 30, 1930) and records of the polarity and strength of magnetic field on 324 days (calendar year 1929). The magnetic fields of 271 of the 346 spot groups examined were regular in sign, 8 were irregular, and 67 groups could not be classified. The solar observers were Ellerman, Hickox, Nicholson, and Richardson.

Work with the spectrohelioscope has been continued at the Solar Laboratory and on Mount Wilson. Hale has published some of his extensive observations with this instrument and perfected the plan for coöperative investigations; 15 observatories and institutions are now planning to take part.

Miss Moore and Richardson have studied the intensities and identifications of lines and bands in the sun-spot spectrum and the atomic and molecular processes involved in their behavior. For sun-spots of medium size Pettit and Nicholson find a nearly linear increase in the energy radiation of spot relative to photosphere between the values 0.21 at $\lambda 0.3\mu$ and 0.81 at $\lambda 1.71\mu$; thereafter the ratio is nearly constant. The ratio of total energy-radiation is 0.477, with a nearly continuous decrease from photosphere to umbra. Resulting temperatures are 4800° K for the umbra of spots and about 5950° for the center of the sun.

St. John has shown that, regardless of intensity, all lines in a given multiplet in the solar spectrum have equal displacements toward the red, and that the excitation potentials at which various atomic transitions occur govern in large degree the presence of the lines in the spectrum, their intensities, and the relative heights to which they rise in the sun's atmosphere.

Other solar-spectrum investigations include Babcock's work in the

infra-red, now extending to λ11634, and his statistical study of the relative numbers of lines of different Rowland intensity; St. John's measures of solar rotation and limb-center displacements; and microphotometric measurements of the contours and intensities of selected multiplets and other groups of lines by Dr. Shane, St. John, and Mr. Woolley.

The monthly mean ratio of the solar energy at $\lambda 0.32\mu$ to that at $\lambda 0.5\mu$ reached the very high level of 1.52 in January, 1930; the lowest value was 1.15 in April. These results are by Pettit, who has also determined the ultra-violet limit ($\lambda 0.293\mu$) of the sky spectrum with two crossed monochromators.

The total solar eclipse of April 28, 1930, was observed at Honey Lake, California. Thin clouds prevented photometric observations, but some of the direct photographs and spectrograms, of which one taken by Dunham shows more than 2,000 bright lines, are of interest.

Photographs of the moon, including two series of motion-picture negatives, have been made by Pease. Dr. F. E. Wright has begun the construction of a large-scale linear map from Mount Wilson photographs, and has designed a small quartz spectrograph with a Wollaston prism for studying the nature of lunar materials.

Pettit and Nicholson find from radiometric measures that the distribution of energy about a unit surface on the moon does not follow the cosine law. The temperature of the sub-solar point derived by different methods indicates that the transmission of the earth's atmosphere between 8μ and 14μ is about 19 per cent greater than generally supposed. The temperatures of the moon and planets heretofore derived must therefore be reduced. The final value for the sub-solar point is 374° K; for the dark side of the moon, less than 120° K. Correction of the observations of Mars made in 1924 gives for the sub-solar point at perihelion 294° K; those of 1926 give 297° K. The temperature at aphelion is 27° lower.

Discovery of the trans-Neptunian planet Pluto at the Lowell Observatory led Nicholson to repeat a search for the planet on photographs taken in 1919 with the 10-inch telescope. Images found on four negatives, combined with recent observations, enabled Nicholson and Mayall to compute a satisfactory orbit.

Most of the photographs of nebulae have been made by Hubble, with some assistance from Mayall. Dr. Duncan obtained several negatives, one of which, with nine hours exposure on the northern part of the nebulous wreath in Cygnus, shows several new filaments. From a plate of Nova Aquilae 1918 he finds that the nebulous envelope, now 23″ in diameter, has been growing fainter and enlarging at a uniform rate. Hubble has counted about 10,000 nebulae on his photographs, and finds a very irregular zone of avoidance along the Milky Way, with a fairly uniform distribution in higher galactic latitudes. In these latitudes the numbers increase with exposure time as though the nebulae were uniformly distributed in space.

Hubble has published his investigation of the distribution of luminosity along the axes of 15 elliptical nebulae. The curve representing the three-dimensional distribution of luminosity is similar to that expressing the distribution of density in an isothermal gas sphere.

To supply the need for accurate photographic and photovisual magnitudes of extra-galactic nebulae Hubble is studying the photometric problems involved, using the method of extra-focal images on a sequence of nebulae in the Virgo cluster. Provisional color indices suggest a color excess in low latitudes which may depend on latitude and not on distance.

Humason has obtained spectrograms of 15 extra-galactic nebulae. More than half are members of five nebular clusters; the remainder are isolated nebulae with apparent radial velocities between +750 and +4100 km/sec. A very faint nebula in the Ursa Major cluster shows a red-shift corresponding to a velocity of +11,500 km/sec, the largest thus far found. Hubble has previously assigned to this nebula a distance of 75,000,000 light-years.

These new results for extra-galactic nebulae extend the observed range in distance twelve-fold and strongly confirm the velocity-distance relationship derived by Hubble, which now depends upon 58 isolated nebulae and 22 in five clusters. Except for a single nebula in the Coma cluster, possibly a field nebula seen in projection, the linear relation between velocity and distance amounting to 500 km/sec per 1,000,000 parsecs is well satisfied by all of the objects. The distances of three clusters of nebulae from recently determined radial velocities are:

Pegasus, 8×10^6; Perseus, 10.5×10^6; Ursa Major, 24×10^6 parsecs.

Van Maanen has measured the trigonometric parallaxes of 17 stars of which eight are dwarfs with absolute magnitudes of +10.0 or fainter. The parallax of B.D. +43°4305 is +0″.213, which places it among the nearest 25 stars known. He has also measured the proper motions of 133 stars in the open cluster N.G.C. 2264 and of six planetary nebulae. The latter range from 0″.001 to 0″.010, corresponding to a mean parallax of about 0″.001. Nine photographs of the stellar nucleus of the spiral nebula N.G.C. 4051 yield the proper motion

$$\mu_\alpha = -0''.003 \pm 0''.0008, \mu_\delta = +0''.015 \pm 0''.0011.$$

It is difficult to account for the large motion in declination on the basis of magnitude or other errors. The spectrum, however, is of the planetary nebula type.

The Mount Wilson Catalogue of Photographic Magnitudes in Selected Areas 1-139 by Seares, Kapteyn, and van Rhijn has appeared in print. Seares and Miss Joyner have derived photovisual magnitudes of faint stars in 12 Selected Areas at +45° and +30° declination. The scale depends partly on diaphragm exposures and partly on polar comparisons, strengthened by averaging the results for three successive areas. A similar investigation is the determination by Seares and Dr.

Sitterly of the photographic and photovisual magnitudes of the southern comparison stars for Eros.

Pease has adjusted the 50-foot interferometer and tested its optical performance with satisfactory results. Fringes have been observed at a mirror separation of 34 feet; the mechanical operation of the instrument is in general excellent.

About 1400 stellar spectrograms have been obtained in the course of numerous investigations. Especial attention has been given to the radial velocities and spectral changes of variable stars and spectroscopic binaries, to stars with emission lines, and to bright stars photographed with high dispersion.

The radial velocities of 741 stars have been published by Adams, Joy, Sanford, and Strömberg, and the velocities of several hundred other stars in the Selected Areas, Boss's Catalogue, and other observing lists, have been measured. Sanford has nearly completed his program for N-type stars, having determined about 65 radial velocities.

Joy has given special attention to the eclipsing variables X Trianguli, RT Sculptoris, W Ursae Minoris, RT Lacertae, RS Canum Venaticorum, and U Sagittae. The combination of spectroscopic and photometric observations has given absolute masses and dimensions for several of these systems. TT Aurigae, components both of type B3, show both stellar and interstellar H and K lines. Observations of U Sagittae, brighter component B9, fainter but larger component G2, made during the total eclipse of 100 minutes determine the slope of the velocity-curve, and hence give the relative masses of the two stars.

Sanford has determined the velocity-curves of the Cepheid variables U Aquilae and DT Cygni, and has nearly completed the orbits of the spectroscopic binaries Boss 5575 and 5846. He finds that the radial-velocity observations of the M-type variable R Lyrae point to an oscillation of 43.48 days in the star's mean period. He has also studied U Monocerotis, AC Herculis, and V Ursae Minoris, having periods intermediate between those of the Cepheids and the long-period variables, and also several others, including α Orionis and ζ Geminorum, for which he has used high-dispersion spectrograms.

Approximate velocity-curves of 10 Cepheids and short-period variables have been derived by Joy, and the periods of several spectrographic binaries by Christie. Observations of ϵ Aurigae with the coudé spectrograph by Adams and Sanford showed the presence of double lines in November, 1929, and February, 1930, which gives added interest to the study of this star.

Merrill and Miss Burwell find that in Me stars the bright-line ratio $H\gamma : H\delta$ rises rapidly from 0.1 to 0.5 shortly before maximum, remains nearly constant for a time, then rises still more rapidly to 2.5 midway between maximum and minimum. The apparent velocities from the bright lines decrease at and shortly after light-maximum to a flat minimum 30-80 days following the maximum. Several bright lines have been newly identified; among them are forbidden iron lines and an

ultra-violet magnesium triplet. The presence of titanium oxide above the level at which the bright lines are produced is suggested as an explanation of the abnormally low intensities of Hα, Hβ, and Hγ relative to Hδ.

Additional spectroscopic investigations include further studies of bright-line B stars by Merrill and Miss Burwell; the discovery and examination of the structure of bright H and K lines in giant stars by Adams and Joy; the correlation of relative line-displacements with excitation potential in the spectra of certain stars by Adams and Sanford; and the essential completion of the spectral classification of faint stars in the Selected Areas by Humason.

Dunham has developed a sensitometer for impressing monochromatic standards on spectrograms, and has used it successfully with the coudé spectrograph. He has also studied various recording devices for the microphotometer, and, in this connection, the possibility of utilizing a short-period galvanometer and amplifier.

Spectroscopic determinations of absolute magnitude and parallax have been continued by Adams and Humason. Revision of the reduction tables for dwarf stars to include additional lines has been completed, and the absolute magnitudes of about 1500 stars have been computed. A comparison of results for 580 stars with those from the trigonometric parallaxes of Schlesinger's Catalogue gives a mean difference of —0.03 mag. The revision of the tables for giant stars of types A to K5 is also complete, and the computation of the absolute magnitudes well advanced.

Strömberg has developed and applied a method for calculating the frequency-distribution of absolute magnitudes of stars from their angular peculiar motions and radial velocities. Among stars of apparent magnitudes 6.0 or brighter, types K0 to K2, frequency-maxima occur at absolute magnitudes —1.8, +0.2, +2.9, and +6.7; among types K3 to K9, maxima are at —2.4, —0.1, and between +4 and +9; and among giant M stars, at —1.6 and +0.1. An analogous method which utilizes the parallactic motions gives for the M stars maxima at —4.5 and —0.2.

King has completed the ionization and temperature classification of 2268 lines in the spectra of the rare earths europium, gadolinium, terbium, dysprosium, and holmium. The introduction of caesium into the electric furnace identifies the enhanced lines, which are extinguished under these conditions. About 800 new lines have been measured for wavelength and many tentatively identified with faint solar lines. A survey of the rich spectra of neodymium and samarium reveals 4500 lines between λ2800 and λ7000 suitable for temperature classification, part of which have already been examined. An interesting feature of these spectra is the probable inclusion of lines of the little-known spectrum of illinium.

King has previously noted that most lines of the rare-earth elements of odd atomic number show hyperfine structure. Among the elements

recently studied, europium, terbium, and especially holmium show this feature prominently. Hyperfine structure in praseodymium lines was studied by Professor Gibbs and Dr. Gartlein of Cornell University in 1929 with the large spectroscopes in the Pasadena laboratory and on Mount Wilson. In coöperation with Dr. Meggers of the Bureau of Standards, King is measuring the wave-lengths of the lines of columbium, another element in which hyperfine structure is conspicuous.

Last year's report referred to the discovery by Dr. Birge and King of a carbon isotope of mass 13. King has now obtained electric furnace spectrograms of better quality on which 15 component lines of the band at λ4744.5 due to the $C^{13}C^{12}$ molecule have been measured, and on which several additional bands involving C^{13} have been detected. Dr. Birge's calculations show that the spacing of these bands agrees within much less than one per cent with the values predicted for a molecule involving C^{13}, and that the mass ratio of 12 to 13 is accurate to one part in 10,000. It now seems probable that the faint band at λ4752 observed in the spectra of some N-type stars is due to the molecule $C^{13}C^{13}$.

Anderson has experimented with the electro-optic shutter as a means for studying the phenomena of electrically exploded wires. Since the transition from the liquid to the gaseous state occurs in much less than a millionth of a second, the rotating-mirror camera fails to record the details of the process, although the magneto-optic shutter showed some years ago that they are most complicated. Calculation indicates that during a part of the short interval of the explosion enormous magnetic fields must exist at the surface of the wire.

In coöperation with Doctors Birge and Giauque, Babcock is measuring the faint isotope bands of oxygen and continuing a search for other very faint members of the newly discovered system of bands. A new band due to $O^{16}O^{16}$ has been found and measured, which, although not contributing directly to the investigation of O^{17} and O^{18}, provides the first precise determination of the vibrational energy of the normal oxygen molecule.

Babcock has compared the Allegheny wave-lengths of 284 lines in the vacuum iron arc with those computed from the wave-lengths in the open-air arc on the basis of known term values by the method he proposed some years ago. The results are most satisfactory and suggest the use of this method as a means of obtaining standards in the region λ1800-λ3300, where direct measurements with the interferometer are difficult.

Babcock has studied further the correlation in the iron spectrum between the levels of the spectroscopic terms and the groups into which the lines have been classified according to pressure, temperature, dissymmetry, and widening. With increase in any one of these characteristics the levels of both upper and lower terms increase continuously in parallel courses.

In his study of radiometers Smith has developed an instrument from which the effects of temperature drift and electrostatic charges have

been practically eliminated, and for which sensitivity is limited by the Brownian movement. The permissible uncertainty from this source thus sets a lower limit to the size of the suspension. The sensitivity at room temperature has been compared with that at the temperature of liquid air, and the effect of atmospheres of hydrogen, helium, and air has been investigated. Used at the 60-inch telescope on Arcturus, one of these instruments gave for a region of the spectrum near $H\alpha$ a deflection of 14 mm at a scale-distance of one meter.

Smith has also designed a simple recording microphotometer having a short-period radiometer as the light-sensitive element, and two telechron motors, one to drive the plate and the other the recording mechanism. In a temporary form the instrument has given excellent results.

Anderson has devised a valuable method for increasing the resolution of close lines on spectrograms and the accuracy of measurement. A cylindrical lens inserted behind the objective of the measuring microscope, with its axis at right angles to the spectral lines, widens enormously each grain on the photograph in a direction parallel to the lines. The grain disappears, and consequently high magnification can be used. Tests on a spectrogram of the iron arc taken with a one-meter concave grating show a three-fold gain in resolution and accuracy of measurement. The cylindrical lens also greatly increases the visibility of faint lines.

The ruling machine has ruled several excellent 4-inch gratings. Two large gratings with long lines, although quite usable, are not of the very finest quality owing to disturbances during ruling. The diamond points have in all cases been shaped to concentrate light in specified orders.

Preparations for Dr. Michelson's measurement of the velocity of light through a line of pipe exhausted to a low pressure are nearly completed. The entire line, one mile in length, has been installed and tested throughout, and the optical system with its controls has been adjusted and operated with satisfactory results.

W. S. Adams, *Director.*

UNITED STATES NAVAL OBSERVATORY

Washington, D. C.

Changes in the Staff. Captain J. F. Hellweg, U.S.N., has succeeded Captain C. S. Freeman, U.S.N., as Superintendent; and Captain V. K. Coman, U.S.N., has succeeded Captain H .G. S. Wallace, U.S.N., as Assistant Superintendent.

Time. Official time is furnished directly through the naval radio stations at Arlington and Annapolis. The feasibility of reradiating Arlington high frequency signals from Mare Island has been demonstrated experimentally. A new chronograph has been developed by which the speed and accuracy of the measurements of the times of the radio signals is increased.

Ephemeris Department. The copy of the Ephemeris for 1933 is practically completed. The copy of *American Nautical Almanac* for 1932 is completed. A supplement giving the Lunar Ephemeris for Navigators has been completed for 1930.

The Ephemeris star list has been increased to 861.

Corrections to the longitude of the Moon were determined from occultations observed at the Naval Observatory, the Union Observatory, and the Tokyo Observatory.

Meridian Astronomy. The 72,330 observations secured with the 9-inch transit circle during the period 1913-1926 are practically all reduced. The resulting catalogue of 10,000 Standard and Intermediary Stars is being compared with other catalogues, and proper motions are being determined. The printer's copy of the catalogue has been started, and the copy of the Sun, Moon, and planet results is partly completed. The introduction is being prepared.

With the 6-inch transit circle 11,050 observations have been made. The objects observed include the Sun, Moon, planets, standard stars, zodiacal stars, and Eros reference stars. There were 3,273 determinations of instrumental constants, and the instrument was reversed 28 times. The flexure was measured by the Bonsdorff method.

The declination observations with the altazimuth have been continued, with 2,047 observations for the year.

A total of 2,036 star observations on 311 plates have been secured with the photographic zenith tube.

Equatorials. Observations with the 26-inch and 12-inch equatorials of occultations, satellites of the planets, asteroids, comets, eclipses of Jupiter's satellites, double stars, stars, and Pluto numbered 322.

Astrographic Work. The sun was photographed on 308 days. Sunspots were found on all the plates. Current solar observations are published monthly in the official *Weather Review,* issued by the Department of Agriculture.

With the 10-inch photographic equatorial 75 observations were secured of asteroids, Neptune, Pluto, and stars.

Publications. Volume XII, *Publications of the U. S. Naval Observatory,* Second Series, was issued. It contained the equatorial observations from 1908 to 1926, the photographic equatorial observations from 1912 to 1924, and the world longitude observations made in 1926 at Washington and San Diego.

The American Ephemeris and Nautical Almanac for 1932, the *American Nautical Almanac* for 1931, and three parts of the *Aeronautical Supplement to the American Nautical Almanac* (*Lunar Ephemeris for Aviators*) including the period from 1 September, 1929 to 31 August, 1930, were issued.

J. F. Hellweg, Captain U.S.N., *Superintendent.*

(To be continued.)

PLANET NOTES FOR MAY, 1931

By CLIFFORD E. SMITH.

The *Sun* will be moving northeast from the central part of Aries to the central part of Taurus. Its position at the beginning of the first and last days of the month will be respectively: R.A. $2^h\ 29^m$, Decl. $+14°\ 43'$; R.A. $4^h\ 27^m$, Decl. $+21°\ 45'$.

The phases of the *Moon* will occur as follows:

Full Moon	May	1	at 11 P.M.	C.S.T.
Last Quarter		9	" 7 A.M.	"
New Moon		17	" 9 A.M.	"
First Quarter		24	" 2 P.M.	"

The moon will be at apogee on May 11 at 7 P.M., C.S.T., and at perigee on May 27 at 10 A.M., C.S.T.

Mercury will be in central Aries. At the end of the month it will be a morning star of magnitude about +1 and will rise about an hour and a half before the sun. Its distance from the earth will vary from about 50 million miles at the beginning of the month to about 80 million miles at the end of the month. On May 13 it will be at aphelion, on May 16 it will be in conjunction with the moon, and on May 27 it will be at greatest elongation west. Its apparent motion among the stars will be retrograde up to the twelfth of the month and thereafter direct.

Venus will continue as a morning star of magnitude about —3, rising about two hours before the sun. Its apparent motion among the stars will be easterly from the central part of Pisces to the central part of Aries. On May 10 it will be in conjunction with Uranus, and on May 15 it will be in conjunction with the moon. Its distance from the earth will vary from about 120 to about 137 million miles. The apparent semidiameter of Venus during this period will be about six seconds of arc.

Mars will be an evening star in western Leo of magnitude about +1. On May 2 it will be at quadrature east of the sun, and thus early in the month it will be on the meridian about sunset. During the middle of the month its distance from the earth will be about 130 million miles, and at that time its apparent semidiameter will be about 3¼ seconds of arc. Conjunction with the moon will occur on May 23.

Jupiter will continue as an evening star in eastern Gemini of magnitude about —1.5, and during the middle of the month it will be on the meridian about 4:00 P.M. On May 15 its distance from the earth will be about 540 million miles and its apparent semidiameter will be about 16 seconds of arc. Conjunction with the moon will occur on May 21.

Saturn will be a morning star in eastern Sagittarius of magnitude about +1. During the middle of the month its apparent semidiameter will be about eight seconds of arc, its distance from the earth will be about 880 million miles, and at that time it will be on the meridian about 4:00 A.M. Conjunction with the moon will occur on May 7.

Uranus will be in the morning sky but near the sun in apparent position since it was in conjunction with the sun early in April. As mentioned in the notes on Venus, Uranus and Venus will be in conjunction on May 10.

Neptune will be in the evening sky in Leo some four or five degrees in an easterly direction from Regulus. Its distance from the earth will be about 2800

million miles, and its apparent semidiameter will be about one and a quarter seconds of arc. On May 24 it will be in conjunction with the moon and on May 25 it will be in quadrature east of the sun. During the latter part of the month it will be on the meridian about 6:00 P.M.

Occultations

VISIBLE AT WASHINGTON.

[From the *American Ephemeris.*]

Date 1931	Star	Mag.	IMMERSION Washington C.T. h m	IMMERSION *a* m	IMMERSION *b* m	IMMERSION Angle E from N °	EMERSION Washington C.T. h m	EMERSION *a* m	EMERSION *b* m	EMERSION Angle E from N °
May 8	40 B.Cap	6.2	1 54	—0.9	+0.6	120	2 52	—1.8	+2.3	214
9	33 Cap	5.3	2 26	—1.2	+1.6	81	3 45	—1.6	+1.6	238
19	406 B.Tau	5.6	20 58	—0.4	+0.2	41	21 28	+1.2	—2.2	330
28	621 B.Vir	6.4	18 34	—0.9	+0.2	118	19 42	—0.9	—0.5	316
28	40 H.Vir	5.1	23 12	—1.1	—1.8	154	0 15	—1.8	—1.1	269
30	40 B.Sco	5.4	18 36	—0.4	+1.1	96	19 33	—0.2	—0.1	316

The quantities in the columns *a* and *b* are given for the purpose of making these predictions useful for any place within 200 or 300 miles of Washington. The procedure is as follows: Subtract the longitude of Washington (77°.1) from the longitude of the place in question; multiply the result, taking the signs into account, by the quantity under *a* for the star to be observed; similarly, with the latitude (38°.9) using *b*; apply the sum of the products, with its proper sign, to the Washington C.T., and obtain the predicted Washington Civil Time for the phenomenon at the place of observation. To obtain Eastern Standard Time it is necessary to add 8.3 minutes to Washington Civil Time.

VISIBLE AT OMAHA AND VICINITY.

Date 1931	Star	Mag.	G.C.T. h m	*a* m	*b* m	P °
May 4	Antares	1.3	2 26	—0.4	—1.0	71
20	406 B. Tauri	5.6	1 58	—0.5	+1.9	68
28	621 B. Virginis	6.4	23 34	—0.2	—1.8	135
29	40 H. Virginis	5.1	4 06	Grazing		191
30	64 G. Librae	5.8	8 50	—1.2	+0.9	108
30	40 B. Scorpii	5.4	23 45	+0.2	—1.5	112

VISIBLE AT MOUNT HAMILTON AND VICINITY.

May 4	Antares	1.3	2 27	+0.6	—0.6	114
22	4 Cancri	6.2	6 00	—0.4	+2.1	66
30	40 G. Librae	5.8	8 16	—1.8	—0.1	118

The approximate times for observers within 300 miles of Omaha can be found by using the constants *a* and *b*, given in the table, according to the formula

$$\text{G.C.T.} = \text{Predicted G.C.T.} + a\Delta\lambda + b\Delta\phi,$$

$\Delta\lambda$ and $\Delta\phi$ in this case being obtained by using the longitude (96°.0) and latitude (41°.3) of Omaha, and subtracting these, respectively, from the longitude and latitude of the place.

For observers within 300 miles of Mount Hamilton, California, the same rule is followed using the longitude (121°.7) and latitude (37°.3) of Lick Observatory.

Only disappearances are given.

Creighton University Observatory. WM. CLETUS DOYLE, S.J.

METEOR NOTES

By CHARLES P. OLIVIER.

It is one of the purposes in writing these notes to bring to the attention of our members recent noteworthy work in the field of meteoric astronomy. This may well fill a real need as some of the articles appear in publications or journals not readily accessible to most persons. Several therefore will receive attention in the following paragraphs.

From Dr. Wm. D. Urry, now at Johns Hopkins University, four reprints on the age of iron meteorites have just been received. They were signed by F. Panath, Wm. D. Urry and W. KoKeck, and the most important appeared in "Zeits. für physicalische Chemie," Abt. A 152. Bd., ½ Heft, and in "Zeits. für Electrochemie," 1930, Nr. 9. Their method consisted in measuring the helium and radium content, from which analysis the age of the meteorite is estimated. In all, 19 results are given, referring to a slightly smaller number of actual falls, as occasionally two fragments were analyzed from the same fall. Using one million years as our unit, one result was 16, one 100, one 120, four <1000, six >1000 and <2000, six 2000 or over. The highest number was 2900.

As no one now believes that our Solar System is less than 2×10^9 years old and many incline to a figure five times larger, so far as these results go they indicate that meteorites were formed after the system as a whole. This is a most unexpected result, and if confirmed will force modification of our theories of the origins of comets and meteors. The writers of the articles seem indeed to incline strongly to the theory of planetary origins—one that has had no recent support from any other quarter. Their analyses seem to have been carried out with the utmost care, and they feel very confident of their results. Brief notes on this subject may be found in *Nature*, 123, 794; 1929, and also in the March, 1930, number. Similar analyses by others, and on other meteorites, will be eagerly awaited.

One of the few observatories at which valuable, systematic work in meteoric astronomy is being carried on is the Observatory of Tartu (Dorpat) under the able direction of Dr. E. Öpik. We therefore welcome the appearance of Tome XXVII, No. 2, of its Publications. The first section by Dr. Öpik himself deals with telescopic meteors, a subject of great importance and of which we know little. Two stations were used for the determinations of parallax, and later one for the gathering of data on their rates and distributions. Similar telescopes of 6 cm aperture, 60 cm focal length, and with fields 6° in diameter were used. The stations were 1.76 km apart, and both telescopes were kept trained on the celestial pole, the observers thus being able to sit in comfort in heated rooms.

The results for 24 meteors, which had trails making an angle of 30° or more with one another, are as follows: 7 meteors of 6.0 average magnitude gave 100 ± 11 km; 8 of 7.6 av. magn. gave 85 ± 8 km; 9 of 8.5 av. magn. gave 78 ± 7 km. The individual heights ranged from 45 to 360 km. All heights refer to the centers of the observed trails, not to the ends. As there seems no good reason to doubt the general validity of these results, even though they are not numerous, they answer one important question; these telescopic meteors appeared lower than the average naked-eye meteor, not higher as had been expected by some. This would mean that the smaller the particle, the lower it would have to penetrate into our atmosphere before it began to burn. Therefore, following the same line of argument, we must turn to the largest masses if we wish to find the greatest

heights at which such bodies become visible. This is supported by the very great heights calculated for the beginning points of many fireballs, of which, by the way, certain writers formerly have been quite skeptical.

Öpik's further result, based upon 456 telescopic meteors, that in direction of motion there is a strong maximum towards the Sun and no maximum in the opposite direction is most surprising and unexpected. The theory of this phenomenon he hopes to treat later.

Altogether we have here the first successful results of a systematic campaign of observers whose whole attention was directed to the subject of telescopic meteors alone. It should encourage others to undertake work as the results are so interesting that they deserve early confirmation or modification. Dr. Öpik is to be heartily congratulated on these first and important results of his telescopic campaign.

The second part of the publication deals with the Orionid meteors, its author being Dr. Rootsman. It is based on an article in *Astr. Nach.*, Nr. 4418, by D. Durango, which contains 144 observations of meteors made on four nights by five observers, some observing for the first time. The original paper clearly shows that its writer had little confidence in the results there published. Despite this, Dr. Rootsman uses it as a basis for a considerable article, in which he discusses the Orionid radiants and orbits. The incomprehensible thing about his paper is his totally ignoring all work done after 1893, while quoting all he could find previous to this. As ten times as much work has been done since that date as before on the Orionids, this procedure makes his discussion practically useless. Why should such an article be published?

For those interested in meteor photography an important paper may be found in *Bulletin of the Harvard College Observatory*, No. 881, again by E. Öpik assisted by Miss Margaret Olmsted. No review will be attempted, but anyone who contemplates work of this kind should certainly study their results most carefully, as much time will be saved thereby which would otherwise be spent in useless experimenting.

Turning now to current observations. On January 22 at about 6:00 P.M., E.S.T., a fine fireball passed west of Philadelphia, heading in general somewhat east of north. Requests in the daily papers led to numerous letters from eyewitnesses, to the most promising of whom questionnaires were then sent. Dr. Fisher of Harvard sent in a number from New England, gathered by him, and other scientists also contributed observations from persons in their vicinity. We regret to say that none has come from Canada and none from south of the starting point. Therefore, despite the fifty-odd observations at hand, it is not going to be any too easy to make a good solution. As the object seems to have been equal to the quarter Moon in brightness, at the hour it appeared thousands must have seen it. Observations from Maryland or Canada would be most valuable.

Since the annual report, about 20 fireball or meteor shower reports have turned up, mostly from ships, referring to 1930. As to 1931, there are 5 for January and 15 for February to hand. Of these latter, 2 refer to a fireball on February 5 at about 8:48 P.M., 3 to one on February 10 at 7:05 A.M., and 2 probably to the same object at about 11:15 P.M. on February 26, all three given in E.S.T. Further observations of any of these objects would be gratefully received. It is obvious that the attempts to collect data on fireballs made by Dr. Fisher, Dr. Wylie, and the writer are rapidly calling the attention of many people to these bodies. Each year more observations come in and more heights can be calculated therefrom.

The following new members are welcomed to the Society with the admonition that we expect new members, as well as old, to take an active part in our work:

J. Leo Kenan, Box 2569, Havana, Cuba.
Charles Earle, 703 N. Caroline Avenue, Atlantic City, New Jersey.
M. L. Evons, 4001 Cedar Lane, Drexel Hill, Pennsylvania.
H. C. Hammond, 1403 Southern Finance Bldg., Augusta, Georgia.
Dr. J. W. MacQueen, 1603 Empire Bldg., Birmingham, Alabama.
L. H. Ketchum, Box 7, Antrim, Pennsylvania.
Joseph Jedes, 3947 Boarman Avenue, Baltimore, Maryland.
J. M. Crothers, 3947 Boarman Avenue, Baltimore, Maryland.
A. R. Allen, 137 Plum Street, Trinidad, Colorado.

Any member who joined the A.M.S. before January 1, 1931, and who did not received a copy of Reprint No. 8 of the Flower Observatory, is requested to inform the writer at once.

Flower Observatory, Upper Darby, Pennsylvania, 1931 March 19.

Fireballs Reported to the University of Iowa

This is a continuation of the list appearing in the March issue of POPULAR ASTRONOMY which closed with the last meteor reported for the year 1930. The first bright meteor reported in 1931 was observed January 9, at 9:40 (Central Standard Time, noon to noon reckoning). It was seen in the southwestern sky from Iowa City, Iowa. The next was observed in the southeastern sky from Iowa City on January 20, at 7:08. Although not in our territory, a meteor observed in New York State on January 22, at 5:10 (6:10 Eastern Standard Time) is included to illustrate the fact that bright meteors appear sometimes to fall in groups. It was bright enough to be reported in newspapers from Syracuse, Elmira, and New York City. On the same evening at 7:15 a meteor was observed in the southern sky from Chicago, and at 9:50 another was observed in the eastern sky by residents of Indianapolis. On the following evening, January 23, at 10:30 a brilliant meteor was observed at Clarinda, Iowa. The five brilliant meteors reported from January 20 to 23 inclusive, show the tendency to groups, often noticed on previous occasions. On January 31, at 9:22, a brilliant meteor was observed in the northern sky from near Decorah, Iowa.

The brightest meteors reported to date in the middle west this year fell on the evening of February 8, at about 9:00. About twenty reports were received, and these apparently refer to two brilliant meteors, both over Minnesota. The first meteor appeared at about 8:50, and was observed by Professor E. C. Johnson at St. Paul, Minnesota, Don W. Faulkner at Hudson, Iowa, and others.

The second meteor appeared at about 9:05 and was observed by Norbert G. Ribble of the U. S. Weather Bureau at Des Moines, Iowa, and others. For many of the reports, it is impossible to say which meteor was observed, but both must have been brilliant. Reports from Minneapolis are that it "cast a vivid bluish white light." Five boys ranging in age from twelve to sixteen came running into the house "with white faces and apparently very much frightened, telling us that Judgement day was now at hand." At Winona, according to newspaper reports, "it suddenly became as bright as day." Both fell near Minneapolis and St. Paul, the first meteor probably within fifty miles of the twin cities, and the second one may have been more than a hundred miles west.

In the November issue of POPULAR ASTRONOMY we referred to the report of an automobile near Crawfordsville, Indiana, being damaged by a meteor. In the March issue we again mentioned this report and stated that investigation indicated

that the damage was probably not caused by a meteorite. Reasons for believing that the damage was not caused by a meteorite are: First, that the probability of a car being struck by a meteorite is exceedingly small. Assuming that one per cent of the meteorites falling in the United States are now being recovered, an authentic report of damage to a car by a meteorite anywhere in the United States should occur not oftener than about once in five hundred years. The probability of any particular report being authentic is, therefore, very near zero. Second, since meteorites reach the earth from only the largest meteors the fall of a meteorite should, if the weather is clear, be accompanied by reports of a brilliant meteor observable at a distance of hundreds of miles, and by detonations heard by everyone in the community where the meteorite was recovered. In spite of the wide publicity given the incident, no meteor which can be associated with the damage to this Ford has been reported, and no detonations were heard in the vicinity of Crawfordsville on that evening. Third, where the direction of fall of a meteorite can be determined, it is always very nearly vertical, and small meteorites fall in an even more vertical directon than do the larger. The angle of about forty-five degrees, indicated by the damaged Ford, appears to be impossible for a meteorite. Fourth, the velocity with which small meteorites strike is normally not very different from that of large hail stones. The velocity necessary to cause this damage appears quite impossible for a small meteorite.

Because of the wide publicity given the meteor explanation (it probably reached about half the nation), an effort was made to secure the damaged parts for study. Through the coöperation of Mr. Shirl Herr of Crawfordsville, they have at last been secured. A preliminary examination indicates that the hole through the hood and radiator of the Ford was probably made with a shot gun, fired with the muzzle perhaps two feet from the hood of the car, and using about number four shot. A few holes have been shot in the hood and radiator from another old Ford, and the similarity appears conclusive. Further experiments will be made in an attempt to duplicate more closely the damage to the Swank car.

C. C. Wylie.

University of Iowa, March 24, 1931.

Meteor Observed in Ohio

The observation of an unusually large meteor is reported to this Observatory by Mr. C. J. Renner, of Crestline, Ohio. The meteor was seen between Mt. Gilead and Galion, Ohio, on returning home from the Perkins Observatory on the night of February 26, 1931, at 11:10 P.M., Eastern Standard Time. The approximate latitude and longitude of the observer was 40° 40′ north and 82° 50′ west.

Mr. Renner writes, "the path of this big meteor was from northeast to southwest, beginning just west of the head of Draco, probably between ξ and δ, and exploding near α Cassiopeia. It was one of those 'once in a lifetime' meteors, leaving a very broad tail and exploding evenly, much like a large 4th of July skyrocket. It proceeded slowly for about 3 seconds before exploding . . . It was of an intense white color, not reddish as many small ones appear." Mr. Renner is of the impression that the trail of the meteor remained luminous for many seconds and was extraordinarily broad. Mr. Renner describes the trail as about the "width of one moon," and the "exploding head appeared to be about six moons in diameter."

That the meteor described above appeared to be of unusual importance is judged from a further statement of the observer's that "we saw the brightest and largest meteor that we ever hope to see."

It is hoped that observations made elsewhere may be reported which will lead to the possible location of the fall.

HARLAN T. STETSON.

Perkins Observatory, Ohio Wesleyan University.
Delaware, Ohio.

A Fireball Observed.—At 8:55 P.M., C.S.T., I was watching the sky when I saw a large ball of fire fall in the southern sky. It broke into five parts, the parts shooting out from the central object and falling farther till they disappeared behind the trees on the horizon. These parts left streaks of fire behind them which were visible, I estimated, for one and a half minutes. It made the sky very bright. It began in the neighborhood of Sirius and fell to the west probably about 5° to 10°. This occurred on the night of February 5, 1931, in Niles, Michigan.

LEROY RUPERT.

COMET NOTES

By G. VAN BIESBROECK.

Many months have passed now without discoveries of comets. The most recent one announced was the object that K. Nakamura detected last November on plates taken at Kyoto (Japan). There still is some doubt as to the nature of this object, which was not observed anywhere else. Bulletin No. 192 of the Kwasan Observatory, Kyoto Imperial University (Japan) gives a report about Mr. Nakamura's efforts to secure photographic records of the comet, which was recognized on plates taken on four successive nights November 13 to 16. On two later nights, November 17 and 18, only a faint trace could be noticed on plates taken with a 16 cm reflector. The magnitude dropped from $13^{M}.5$ on November 13 and 14 to $14^{M}.5$ on November 16 and fainter than that ($<14^{M}.5$) on November 18. This rapid fading evidently accounts for the inability of other observers to locate the object on later dates. The discoverer gives a list of nine positions measured on plates exposed partly with a 11 cm Triplet and partly with a 16 cm reflector; both instruments, made by Nakamura himself, were attached to a 30 cm Cooke refractor, used as a guiding telescope. The positions, especially the last ones, are only approximate but they seem to lie on a smooth curve. There has not been time to complete the numerical discussions of these data, so that the nature of the object, comet or asteroid, is still in question. The fact that Mr. Nakamura on November 15 examined the region visually and caught glimpses of a faint nebulous object only a few seconds in diameter in the expected position is no sufficient proof of the cometary nature. There are quite a number of small nebulae in this region, some of which were suspected by the writer to be the comet on November 21, until it was found that they did not move. Mr. Nakamura may also have been misled in his visual examination on November 15 by some of these small nebulae. But the fact remains that the object recorded on so many plates, showed a motion that would be very unusual for an asteroid.

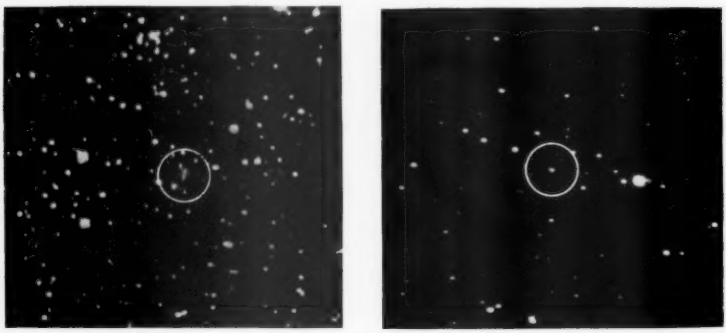
It is safe to say now that ENCKE'S COMET will not be observed until next June, and then only by southern observers. Plates showing stars as faint as 14^{M} were obtained here March 7 and did not reveal the presence of the comet which was not expected to be much brighter on that date. No long exposures can be

secured since the field of the comet moves farther and farther west into the evening sky.

Periodic Comet Tempel II is now also lost in the vicinity of the sun. The last observation secured here on February 14 makes the period of visibility 172 days at this apparition, but during all that time the object has remained very unfavorably placed for observation and it never was brighter than 10^{M} (October, 1930). The Johannesburg and Yerkes Observatories seem to be the only ones where the comet has been observed.

Comet 1927 IV (Stearns) was photographed again by the writer on March 12, four years and two days after the discovery! It appears on the plate as a tiny round object, only a few seconds in diameter and near the limit of what can be measured. The brightness was between 17th and 18th magnitude. The comet was then in conjunction with the sun and if further observations are secured it will be in the morning sky.

After its unusual behavior in February, reported last month, Comet 1925 II (Schwassmann-Wachmann) seems to have come back to a more normal appearance. In the figure herewith I have tried to illustrate the remarkable change that this comet has undergone recently. On the left side we see the comet in what might be called a normal aspect: a hazy round spot about 2′ in diameter



1930 Dec. 16 1931 Feb. 11

Change in Aspect of Comet 1925 II
from photographs taken with the 24-inch reflector.

with an unsharp central nucleus. It is very difficult to reproduce the faint coma but my colleague, Dr. F. E. Ross, skilfully reenforced the image by successive copying. This exposure was made on December 16, 1930, and the comet was then projected on a rich background of stars in the Milky Way. To the right and on the same scale of about 20″ to the millimeter is seen the same object recorded February 11, 1931. At first sight it does not appear different from the surrounding stars, which are slightly elongated because the telescope was guided for the motion of the comet during the exposure of 20 minutes. The cometary image indicated by the circle is reduced to a little bright disc; close examination of the original plate reveals, however, a slight diffuseness at the edge, which is not as clean-cut as that of the star images. But the main coma has entirely vanished. The distances in astronomical units at those two dates were:

	Dec. 16, 1930	Feb. 11, 1931
Distance of Comet from Earth	6.10	6.33
Distance of Comet from Sun	7.00	7.05

The differences are inappreciable and can in no way account for the unusual behavior of the comet. The weather has not given an opportunity to watch the object closely in March but on March 10 it again appeared very much as it did last December, namely as a round coma with central condensation, the total brightness corresponding to that of a 16^M star. The region of the comet will soon be too far west for further observations at this opposition, the third one after the discovery in November, 1927. It is evident that it will be possible to follow this comet year after year all the way in its 16 year cycle around the sun.

In the second part of the night COMET 1930 *b* (BEYER) can still be recorded as a round coma some 10″ in diameter, with little central condensation. On March 20 I found the correction of the Berkeley Ephemeris (see p. 156):

$$(O-C) \text{ in } \alpha = -6^s; \text{ in } \delta = +3''.3,$$

and the brightness was estimated as 15^M. Fully a year has now elapsed since the object was discovered 1930 March 11 by Beyer but photographic records going as far back as 1929 October 8 have been secured with the Franklin-Adams camera at Johannesburg in South Africa so that the comet has now been followed for nearly eighteen months. Several more months will be added to this duration before the comet becomes too faint for further measure.

Williams Bay, Wisconsin, 1931 March 23.

VARIABLE STARS

Monthly Report of the American Association of Variable Star Observers for February, 1931

In spite of the excessive amount of cloudy weather reported from all stations, the number of observers, the number of variables observed, and the number of observations contributed is not far below that of the corresponding months during previous years. More than two thousand observations were contributed by thirty-two observers on four hundred and nine variables. The number of observations contributed on the special irregular variables is commendable, and the results on the whole indicate the value of these observations when plotted. Each and every star on this special list requires very special attention, particularly so the variable U Geminorum, which has not been observed at maximum for more than a year.

We welcome initial observations from three new members and observers this month: Herr Walter Theile of Marburg, Germany; Mr. Charles A. MacPherson of Edgar, Montana; and Rev. James E. Kline, C.S.C., of Notre Dame, Indiana. It is also a pleasure to welcome back to the ranks of active observers, Dr. B. H. Dawson of the Astronomical Observatory at La Plata, Argentina.

After remaining faint for at least a period of six months, the variable star SU Tauri, one of the few which belong to the R Coronae class of variable, we find that this star is now on the rise to maximum. Whether or not it retains its maximum before dropping to another minimum, remains yet to be seen.

According to reports in the several astronomical magazines, the planet Eros has not been neglected as far as visual observations are concerned by some of our members, especially those located in Japan and Germany.

VARIABLE STAR OBSERVATIONS RECEIVED DURING FEBRUARY, 1931.

Dec. 0 = J.D. 2426311; Jan. 0 = J.D. 2426342; Feb. 0 = J.D. 2426373.

J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
V SCL	T CAS	S CET	U CAS	W CAS	U PSC
000339	001755	*001009*	004047	004958	011712
320[13.3 En	350 7.7 Th	324 7.9 Ch	379 9.1 Bw	353 9.0 Ah	333 13.8 Ch
321[13.3 Bl	350 8.4 Jo	330 8.4 Tf	383 9.1 Sf	353 8.4 Jo	352 14.1 L
329[13.3 En	351 8.1 Ah	334 8.2 Ch	386 9.7 Md	354 9.1 Ah	382[12.8 Mg
332 13.7 Dr	351 7.8 Th	339 8.3 Tf	392 8.6 Bw	357 8.7 Pt	R SCL
S SCL	352 8.2 Ah	348 8.7 L	RW AND	358 8.8 BL	*012233a*
001032	353 7.9 Ah	350 8.6 Jo	004132	360 8.5 Jo	292 8.4 Kd
279 6.6 Kd	353 7.6 Jo	351 8.7 Mp	326 9.7 Ch	362 8.7 BL	326 7.2 Dw
292 6.6 Kd	354 7.9 Ah	353 9.4 Tf	330 9.3 Tf	364 8.5 Jo	329 7.8 Kd
312 7.0 Bl	357 7.3 Pt	353 8.9 Jo	334 9.0 Th	368 9.0 Bw	333 8.0 Kd
320 7.5 En	360 7.6 Th	357 9.2 Pt	336 9.5 Th	369 8.8 BL	355 7.8 Kd
321 7.7 Bl	360 7.7 Jo	358 9.3 Sf	339 9.4 Tf	370 8.9 BL	RS SCL
322 7.8 Kd	361 7.2 Mp	360 9.0 Jo	348 9.7 L	375 9.1 BL	012233b
326 7.7 Dw	361 7.4 L	363 10.0 Sf	351 10.4 Th	377 8.8 B	237[14.0 Dr
329 8.0 Dr	364 7.5 Jo	364 9.4 Jo	353 10.1 Tf	377 8.6 Fd	RZ PER
329 7.9 En	365 7.8 Ah	373 10.3 L	356 10.4 Jo	378 9.1 BL	012350
330 7.9 Kd	369 7.6 Th	377 10.7 Sf	357 9.9 Pt	379 9.2 BL	325 10.2 Ch
332 8.4 Bl	377 7.6 B	T SCL	360 10.0 Jo	383 9.0 BL	347 9.3 L
332 8.0 Dr	R AND	*002438a*	373 11.2 L	384 9.2 BL	361 9.7 L
333 8.2 Kd	001838	321 13.2 En	387 11.8 Md	U TUC	377 10.2 B
339 8.5 Bl	327 6.8 Ch	326 13.1 Dw	V AND	*005475*	386 10.9 Md
355 8.8 Kd	355 7.0 Fd	329 13.0 Dr	004435	312[14.2 Bl	392 10.6 Md
357 9.0 Pt	341 6.5 Fd	329 13.2 En	326 11.9 Ch	323[13.7 En	R PSC
X AND	341 6.8 Ch	RR SCL	X SCL	326 13.7 Dw	012502
001046	349 6.7 Fd	*002438b*	*001435*	329 14.0 Dr	327 10.0 Ch
329[13.2 Ch	350 6.8 Jo	326 13.0 Dw	312 11.8 Bl	333[13.7 En	358 11.3 Pt
366[13.4 Bw	351 6.8 Ah	T PHE	321 12.0 Bl	X CET	RU AND
379[13.4 Bw	352 6.9 Ah	*002546*	321 12.1 En	*010102*	013238
T CET	353 6.9 Ah	321[14.1 Bl	332 13.3 Bl	329 9.0 Ch	319 11.3 Ch
001620	353 6.9 Jo	329[13.0 En	333 13.2 En	347 10.0 L	335 10.9 Ch
279 6.5 Kd	354 7.0 Ah	W SCL	RR AND	358 10.6 L	347 10.7 L
293 6.2 Kd	357 6.9 Pt	*002833*	004533	358 11.0 Pt	358 10.5 Pt
330 5.8 Kd	357 7.0 GD	321 12.8 En	326 11.2 Ch	U SCL	361 10.3 L
330 5.7 Tf	360 6.9 Jo	321 13.0 Bl	368 9.3 B	*010630*	375 10.5 Ma
333 6.0 Kd	362 7.2 GD	326 13.3 Dw	377 9.6 Mg	321[13.2 Bl	377 10.0 Mg
339 5.7 Tf	364 7.2 GD	329 13.1 En	RV CAS	332[13.5 Dr	378 10.1 B
352 5.8 L	364 7.0 Jo	332 13.3 Dr	004746a	U AND	386 10.5 Md
353 5.6 Tf	365 7.0 Ah	Y CEP	357 12.0 Pt	010940	Y AND
T AND	366 6.9 Mg	003179	364 11.6 Sf	326 12.2 Ch	013338
001726	368 7.1 Fd	352 15.2 L	368 11.1 B	347 10.9 L	319 10.0 Ch
324 11.8 Ch	369 7.3 Ah	α CAS	370 11.3 Sf	361 11.6 L	335 11.0 Ch
334 11.5 Ch	375 7.2 Ma	003656	377 11.5 Sf	368 11.0 B	347 11.5 L
357 9.4 Pt	377 7.4 Mg	378 2.6 Mc	377 11.6 Fd	377 11.8 Mg	358 12.3 Pt
360 9.4 Jo	377 7.3 Fd	383 2.8 Mc	383 11.6 Sf	UZ AND	361 12.3 L
360 9.4 Th	378 7.9 B	387 2.2 Mc	— CAS	011041	375[12.1 Ma
360 9.2 Bg	378 8.0 GD	U CAS	004746b	326 11.0 Ch	377 12.2 Mg
368 9.1 B	383 7.8 Fd	004047	357 10.9 Pt	352 11.2 L	387[12.4 Md
369 9.3 Th	S TUC	326 9.9 Ch	364 10.7 Sf	368 12.3 B	X CAS
384 8.4 Bg	*001862*	348 8.3 L	370 10.7 Sf	375 12.6 Ma	014958
384 8.5 Md	312 11.0 Bl	357 8.1 Pt	377 10.8 Sf	S PSC	356 12.2 Mp
T CAS	320 11.9 En	358 8.5 Sf	377 11.4 Fd	011208	358 11.9 Pt
001755	321 12.0 Bl	361 8.2 L	383 10.8 Sf	352 14.7 L	375 12.0 Mp
327 8.2 Ch	326 12.2 Dw	363 8.5 Sf	W CAS	379[13.2 B	377 12.2 B
333 8.4 Th	329 12.4 En	368 8.6 Bw	004958	S CAS	U PER
339 8.4 Th	332 12.2 Dr	370 8.5 Sf	326 9.4 Ch	011272	015254
341 7.8 Ch	332 12.4 Bl	377 8.6 Sf	350 8.7 Jo	326[13.2 Ch	325 8.3 Ch
345 7.5 Mp		377 8.6 B	351 9.3 Ah	377[11.5 Fd	358 8.7 BL
348 7.5 L		377 8.2 Fd	352 9.0 Ah	384[13.2 Bg	358 7.5 Pt

VARIABLE STAR OBSERVATIONS RECEIVED DURING FEBRUARY, 1931.

J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
U PER	o CET	R CET	R HOR	R PER	T CAM
015254	*021403*	*022000*	*025050*	032335	043065
362 8.6 BL	321 9.1 En	383 9.0 Sf	312 12.5 Bl	353 14.2 L	321 11.0 Ch
369 8.7 BL	324 9.0 Ch	RR PER	321 12.5 Bl	377 12.6 Mg	344 12.5 L
370 8.6 BL	330 9.2 Tf	022150	323 12.6 En	388 12.4 Md	358 13.4 Pt
375 8.8 BL	332 9.2 Ch	325 11.5 Ch	326 12.5 Dw	NOV PER	362 12.1 BL
377 8.3 B	333 9.3 En	353 12.4 L	329 12.2 Dr	032443	372 13.5 L
378 8.7 BL	339 9.1 Tf	358 12.7 Pt	332 12.4 Bl	358 13.6 Pt	RX TAU
379 8.6 BL	348 9.4 L	383 13.5 Gc	333 12.5 En	T FOR	043208
383 8.7 BL	350 8.8 Jo	R FOR	339 12.3 Bl	*032528*	323 12.7 Ch
384 8.8 BL	351 9.4 Ah	*022426*	349 12.0 Sl	348 8.8 L	350 13.5 L
XX PER	352 9.5 Ah	312 10.3 Bl	353 11.9 Sl	370 8.8 L	358 13.6 Pt
015654	353 9.5 Ah	321 10.8 Bl	368 11.3 Sl	U ERI	R RET
325 8.4 Ch	353 9.5 Tf	332 10.0 Bl	368 10.7 Dr	*034625*	*043263*
S ARI	353 9.1 Sl	339 9.4 Bl	T HOR	325[12.6 En	321 10.1 En
015912	358 9.2 BL	U CET	*025751*	333[12.6 En	321 10.3 Bl
352 15.0 L	358 9.4 Pt	*022813*	312 8.3 Bl	350 13.3 L	323 10.0 En
R ARI	360 8.9 Jo	358 12.1 Pt	321 8.0 Bl	T ERI	329 9.8 Dr
021024	360 9.3 Bg	RR CEP	325 7.8 En	*035124*	332 9.6 Bl
326 9.2 Fd	362 9.3 BL	022980	329 7.7 Dr	325 12.0 En	339 9.0 Bl
328 9.4 Ch	363 9.7 Sf	347 9.9 L	332 8.7 Bl	329 13.1 Dr	349 8.6 Sl
335 8.9 Fd	365 9.5 Ah	351 10.3 Mp	333 8.1 En	333 12.1 En	353 8.3 Sl
341 8.4 Fd	368 9.2 Sl	358 10.9 Pt	339 8.3 Bl	W ERI	355 7.9 Dr
341 9.0 Ch	370 9.4 L	361 10.4 Mp	368 10.0 Dr	*040725*	360 7.6 Dr
348 8.5 L	375 9.3 Bg	361 9.9 L	U ARI	329 10.9 Dr	368 7.4 Sl
351 8.6 Ah	375 9.1 BL	R TRI	030514	R TAU	X CAM
352 8.2 Ah	378 9.0 BL	023133	323[13.3 Ch	042209	043274
353 8.3 Ah	378 9.3 Sf	293 7.8 Kd	350[14.5 L	323 12.5 Ch	321 12.4 Ch
354 8.2 Ah	379 9.0 BL	318 8.8 Ch	X CET	359[13.0 Bg	348 11.9 L
358 9.0 Pt	383 9.3 Sf	328 9.0 Ch	*031401*	375[12.0 Ma	358 10.8 Pt
358 8.5 L	384 9.1 BL	330 9.4 Tf	324 9.4 Ch	384[13.0 Bg	372 10.5 L
364 9.2 GD	S PER	334 9.4 Kd	347 10.3 L	W TAU	R DOR
365 8.8 Ah	021558	350 9.6 Jo	350 10.0 Jo	042215	*043562*
375 8.9 Ma	352 9.6 Ah	351 9.5 Ah	353 10.3 Jo	323 10.6 Ch	312 5.6 Bl
377 8.7 B	353 9.6 Ah	352 9.7 Ah	358 10.5 Jo	326 10.4 Fd	321 5.7 Bl
377 9.5 Fd	358 9.4 Pt	353 9.7 Ah	358 10.8 Pt	335 10.1 Fd	321 5.5 En
378 9.6 GD	358 9.4 BL	353 10.4 Tf	361 11.2 Sf	339 10.3 Tf	329 5.4 Dr
383 10.2 Fd	362 9.4 BL	354 9.9 Ah	363 11.2 Sf	341 10.2 Fd	332 5.5 En
W AND	368 9.4 Sz	358 10.0 Ft	364 11.0 Jo	350 10.6 Jo	332 6.0 Bl
021143a	369 9.5 BL	360 9.6 Jo	377 11.4 Fd	350 10.8 L	339 6.1 Bl
378[13.1 P	370 9.6 BL	364 9.8 Jo	Y PER	353 10.6 Jo	349 5.6 Sl
T PER	375 9.5 BL	364 11.0 Sf	032043	353 10.6 Tf	353 5.6 Sl
021258	378 9.5 BL	365 10.6 Ah	325 9.0 Ch	358 10.8 Pt	368 5.7 Sl
352 8.6 Ah	378 9.2 B	375 10.8 Ma	350 8.4 Jo	360 10.0 Jo	368 6.1 Dr
353 8.6 Ah	379 9.5 BL	377 11.7 Sf	351 9.4 Ah	364 9.4 Jo	R CAE
358 8.7 Pt	383 9.6 BL	377 11.2 B	352 9.6 Ah	368 10.2 Al	*043738*
358 8.8 BL	384 9.4 BL	383 11.6 Sf	353 9.7 Ah	368 10.7 Fd	312 9.7 Bl
362 8.7 BL	R CET	W PER	354 9.7 Ah	373 10.9 L	321 10.2 Bl
369 8.6 BL	*022000*	024356	356 8.8 Jo	377 10.6 Fd	329 10.3 Dr
370 8.6 BL	318 10.5 Ch	325 9.1 Ch	358 9.0 Pt	377 10.0 B	332 10.6 Bl
375 8.6 BL	324 9.1 Ch	326 8.9 Fd	358 9.0 BL	383 10.2 Fd	332 10.6 En
378 8.6 BL	348 7.5 L	350 8.5 Jo	360 8.8 Jo	387 10.0 Al	339 10.7 Bl
379 8.7 BL	350 7.7 Jo	356 8.6 Jo	362 9.2 BL	S TAU	360 11.1 Dr
383 8.8 BL	358 7.7 Sf	358 8.7 Jo	364 8.9 Jo	042309	R PIC
384 8.7 BL	358 7.9 L	358 8.6 Pt	369 9.3 BL	359[13.0 Bg	*044349*
Z CEP	360 8.0 Jo	360 8.7 Jo	375 9.6 BL	375[11.4 Ma	312 8.4 Bl
021281	361 7.8 Sf	360 8.6 Bg	378 9.8 BL	384[13.0 Bg	321 7.5 Bl
353 14.2 L	363 8.0 Sf	368 8.7 B	379 9.8 BL		329 7.7 Dr
361[12.6 Mp	375 8.5 Bg	379 9.0 Bw	383 10.0 BL		332 7.8 En
	377 8.5 Sf		384 10.0 BL		332 7.6 Bl

VARIABLE STAR OBSERVATIONS RECEIVED DURING FEBRUARY, 1931.

J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs.

R PIC
044349
339 7.6 Bl
355 7.9 Dr
360 8.0 Dr

V TAU
044617
323 10.4 Ch
338 12.1 Ch
358 13.6 Pt
366 13.2 Mg
382 13.4 Mg

R ERI
045016
383 5.8 Fd

R ORI
045307
323 9.6 Ch
344 9.5 L
370 10.2 L
377 10.0 B
382 10.5 Mg
384 11.4 Md
393 11.6 Md

R LEP
045514
324 5.6 Ch
330 5.5 Tf
339 5.7 Tf
349 5.4 Sl
350 6.5 Jo
350 6.1 L
353 5.5 Sl
353 6.4 Jo
353 5.4 Tf
358 6.0 Pt
360 6.5 Jo
368 7.0 Fd
368 5.5 Sl
370 5.5 Tf
371 6.0 Bc
373 5.6 L
378 6.1 Ma
383 6.8 Fd

V ORI
050003
323 10.8 Ch
344 11.9 L
358 12.7 Pt
362 12.6 Bg
373 13.2 L
378 13.4 Bg
384 13.7 Bg

T LEP
050022
312 9.8 Bl
321 9.9 Bl
323 10.3 En
332 9.5 Bl
339 9.5 Bl

T LEP
050022
350 8.7 Jo
353 8.7 Jo
358 9.0 Pt
360 8.5 Jo
377 8.0 B

S PIC
050848
312 8.2 Bl
321 7.5 Bl
321 7.5 En
329 7.4 Dr
332 7.5 En
332 7.0 Bl
339 7.3 Bl
355 7.5 Dr

R AUR
050953
321 11.7 Ch
358 13.0 Pt

T PIC
051247
312 12.8 Bl
321 14.0 Bl
329 13.6 Dr
360 13.6 Dr

NOV TAU
051316
353 14.7 L

T COL
051533
312 10.0 Bl
321 9.4 Bl
323 8.9 En
329 8.6 Dr
332 8.6 En
332 8.5 Bl
338 8.4 En
339 8.4 Bl
355 7.7 Dr
360 7.2 Dr

S AUR
052034
326 9.0 Fd
350 8.6 Jo
353 8.6 Jo
356 8.6 Jo
358 8.8 Jo
358 8.1 Pt
362 9.1 BL
364 8.8 Jo
368 9.0 Fd
369 9.3 BL
375 9.2 BL
377 9.7 Fd
378 9.3 BL
379 9.4 BL
383 9.1 Fd
383 9.3 BL

S AUR
052034
384 9.4 BL

W AUR
052036
353 13.9 L
382 12.4 Mg

S ORI
052404
358 13.1 Pt
377 12.2 B
383 13.0 Mg

T ORI
053005a
344 11.0 L
347 11.2 L
348 10.9 L
349 10.3 L
350 10.2 L
350 10.0 Jo
352 10.3 L
353 10.3 L
353 10.1 Jo
354 10.3 L
356 10.3 Jo
356 10.5 Pt
357 10.5 Pt
357 10.4 L
358 10.4 L
358 10.5 Pt
359 10.6 Pt
360 10.6 Jo
364 10.5 Pt
364 10.3 Jo
366 10.1 Pt
366 10.3 L
368 9.9 Fd
368 10.4 Pt
369 10.3 L
370 10.4 L
373 10.4 L
375 10.9 Pt
375 11.1 Ma
376 11.1 Ma
376 11.0 Pt
377 10.8 Pt
377 11.1 Ma
377 10.2 Fd
378 10.7 Pt
378 11.1 Ma
379 10.4 B
383 10.0 Gc
383 9.8 Fd
383 10.4 Pt

AN ORI
053005t
375 11.4 Ma
376 11.3 Ma
377 11.4 Ma
378 11.2 Ma

S CAM
053068
358 8.4 Pc
362 8.6 BL
369 8.7 BL
375 8.6 BL
378 8.6 BL
379 8.7 BL
383 8.8 BL
384 8.7 BL

RR TAU
053326
347 11.2 L
348 11.2 L
350 11.1 L
352 12.0 L
354 11.2 L
357 12.7 L
358 12.2 L
361 12.3 L
366 12.3 L
370 13.5 L
373[13.0 L

RV AUR
053337
358[12.4 Pt
366[13.4 Mg
368[12.7 Pc
383[13.4 Gc

U AUR
053531
348 11.8 L
353[11.0 Ah

SU TAU
054319
347 12.9 L
348 12.9 L
350 12.8 L
352 12.8 L
354 12.8 L
356 13.0 Pt
357 12.7 L
358 12.8 Pt
358 12.5 Pc
364 12.8 Pt
366 13.1 Pt
366 12.9 L
366 13.1 Mg
368 12.6 Pt
370 13.1 L
376 13.3 Ma
377 13.2 Ma
378 13.0 Ma
378 13.2 Pt
383 12.8 Pt
383 12.3 Pc
383 12.6 Ma

S COL
054331
312 11.8 Bl

S COL
054331
321 12.1 Bl
323 12.5 En
332 12.6 En
332 12.5 Bl
368 13.6 Dr

Z TAU
054615a
350 13.8 L
377 13.0 Ma

RU TAU
054615c
350 12.0 L
377 12.3 Ma

R COL
054629
312 9.7 Bl
321 10.2 Bl
324 10.9 En
332 10.5 Bl
338 11.2 En
339 10.8 Bl
355 12.2 Dr

α ORI
054907
350 0.6 L
352 0.2 Sl
358 0.2 Sl
368 0.0 Sl
378 0.4 Mc
387 0.4 Mc

U ORI
054920a
326 7.3 Fd
335 7.3 Fd
341 7.9 Fd
349 7.7 Fd
349 6.8 Sl
350 7.6 Jo
351 7.9 Ah
352 7.8 Ah
353 7.0 Sl
353 7.6 Ah
354 7.9 Ah
356 7.8 Jo
358 7.7 Jo
358 7.6 Pt
364 7.9 Jo
365 8.1 Ah
368 8.4 Fd
369 8.3 Ah
377 7.4 Fd
378 9.2 Mc
381 8.6 GD
383 8.5 Fd

UW ORI
054920b
377 10.8 Fd

Z AUR
055353
326 10.9 Fd
349 10.4 Fd
356 9.8 Pt
357 9.7 Pt
358 10.0 Pt
359 10.1 Pt
364 10.0 Pt
366 10.0 Pt
368 10.0 Pt
368 9.8 Fd
375 10.0 Pt
376 10.1 Pt
377 10.0 Pt
377 10.4 Fd
378 10.1 Pt
383 10.1 Pt
383 9.7 Fd

R OCT
055686
312 11.2 Bl
321 11.4 Bl
332 11.5 Bl
332 11.5 En
339 11.5 Bl
368 12.1 Dr

X AUR
060450
348 10.9 L
358 9.3 Pt
368 9.3 Pc
372 8.9 L

V AUR
061647
350 12.2 L

V MON
061702
358 12.1 Pt

AG AUR
062047
346 9.4 L
368 9.7 L

R MON
063308
358 12.0 Pt

NOV PIC
063462
321 8.2 En
332 8.2 En
337 8.1 En

S LYN
063558
352 13.3 L

X GEM
064030
366 8.0 Mg

Y MON
065111
330 8.9 Tf

VARIABLE STAR OBSERVATIONS RECEIVED DURING FEBRUARY, 1931.

J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs.

Y MON
065111
339 9.1 Tf
349 8.8 L
350 9.2 Th
353 9.0 Tf
358 9.6 Pt
369 9.4 Th
370 9.5 L
377 9.6 Ma
384 10.2 Bg

X MON
065208
326 9.4 Dr
330 9.3 Tf
339 9.4 Tf
347 8.4 L
353 9.0 Tf
358 8.8 L
359 8.6 Dr
360 8.5 Dr

R LYN
065355
339 10.9 Tf
344 10.7 L
353 11.3 Tf

RS GEM
065530
377 12.2 Ma

Z CMA
065911
349 10.0 Sl
353 10.0 Sl
368 10.0 Sl

V CMI
070109
344 13.4 L
358 13.5 Pt
379 13.3 Bw

R GEM
070122a
350 7.5 Jo
351 7.7 Ah
352 7.8 Ah
353 7.7 Ah
353 7.6 Jo
354 7.7 Ah
358 6.8 Pt
358 7.6 Jo
364 7.6 Jo
365 7.6 Ah
368 6.5 Al
368 7.8 Fd
369 7.8 Ah
377 7.8 Fd
379 7.7 B

Z GEM
070122b
358 12.4 Pt
368[11.6 Fd

TW GEM
070122c
358 7.7 Pt

R CMI
070310
344 11.0 L
350 10.7 Jo
353 10.5 Jo
358 11.7 Pt
358 10.5 Pc
364 10.8 Sf
368 9.9 Pc
377 10.0 Pc
377 10.7 Sf
383 10.5 Sf
383 10.0 Pc

R VOL
070772
323 12.0 En
326 10.3 Dr
332 11.4 En
360 9.8 Dr

L_2 PUP
071044
326 4.8 Dr
329 4.9 Dw
330 4.7 Dr
349 4.1 Sl
355 4.1 Dr
357 4.1 Sl
359 4.4 Dr
368 4.3 Dr
368 4.3 Sl

V GEM
071713
344 12.4 L

S CMI
072708
330 9.9 Tf
335 10.3 Fd
341 10.0 Fd
341 10.3 Ke
353 10.6 Jo
353 9.8 Tf
358 10.3 Ke
358 10.6 Pt
360 10.9 Jo
366 10.8 Ke
368 11.7 Al
368 11.0 Pc
368 10.7 Ke
377 11.7 Fd
383 12.0 BL
384 12.1 BL

T CMI
072811
344[14.7 L

Z PUP
072820b
323 9.0 En

Z PUP
072820b
333 9.0 En
338 9.0 En

S VOL
073173
321[13.2 Bl
332[12.8 En
360 13.7 Dr

U CMI
073508
349 8.4 L
358 8.8 Pt
370 9.2 L

S GEM
073723
350 9.8 Jo
353 9.9 Jo
358 10.0 Pt
358 10.0 Pc
360 10.0 Jo
364 10.1 Jo
368 11.0 Pc
383 12.1 Gc

W PUP
074241
312 9.2 Bl
321 10.0 Bl
323 11.5 En
326 10.5 Dr
329 10.7 Dr
332 11.3 Bl
333 11.7 En
339 12.1 Bl
360 11.9 Dr
368 10.3 Dr

T GEM
074323
350 8.7 Jo
351 9.1 Ah
352 9.3 Ah
353 9.2 Ah
353 9.2 Jo
354 9.2 Ah
358 9.5 Pt
360 9.3 Jo
364 9.5 Jo
368 10.3 Bw
377 10.4 Ma
379 10.8 B
384 11.2 Bw

U PUP
075612
366[12.5 Bw
384[12.5 Bw

R CNC
081112
346 10.2 L
364 10.5 Sf
369 10.6 L
377 10.5 Sf
378 10.1 Mc

R CNC
081112
358 10.2 Pc
358 10.2 Pt
365 10.0 Ah
383 9.6 Pc

V CNC
081617
348 8.0 L
351 8.0 Ah
352 8.0 Ah
353 7.8 Ah
354 7.9 Ah
358 8.0 Pt
365 8.2 Ah
366 8.1 Ke
369 8.3 Ah
370 8.0 L
387 9.4 Mc

RT HYA
082405
364 8.4 Pt

R CHA
082476
312 8.6 Bl
321 8.6 Bl
323 9.0 En
332 9.5 En
332 9.6 Bl
339 9.3 Bl

U CNC
083019
348 11.1 L
366 12.2 Bw
370 13.1 L

S HYA
084803
364 11.1 Pt
383 11.4 Fd

T HYA
085008
349 8.5 L
364 7.7 Pt
370 7.7 L
379 7.9 B
383 7.7 Fd

T CNC
085120
364 9.3 Pt

T PYX
090031
321 [t Bl
332 [t Bl

V UMA
090151
352 8.8 Ah
353 8.8 Ah
354 8.9 Ah
358 8.5 Pc
360 8.6 Jo

V UMA
090151
383 10.8 Sf

W CNC
090425
354 14.2 L
358[12.8 Pc

RX UMA
090567
346 10.9 L
369 11.2 L

RW CAR
091868
324[12.8 En
332[13.3 Bl
359 13.2 Dr

Y VEL
092551
324[12.4 En
332[12.9 Bl

R CAR
092962
312 5.6 Bl
324 6.3 En
326 6.3 Dr
332 6.5 Bl
333 6.6 En
339 7.0 Bl
353 7.2 Sl
355 7.4 Dr
357 7.4 Sl
368 8.0 Sl

X HYA
093014
364 8.2 Pt
383 8.6 Fd

Y DRA
093178
354 13.1 L

R LMI
093934
358 12.4 Pc
364 12.6 Pt
366 12.7 Ke

RR HYA
094023
326[14.0 Dr
359 14.0 Dr
370[13.0 L

R LEO
094211
335 9.7 Fd
341 9.1 Fd
350 8.7 Jo
352 8.8 Ah
353 8.8 Ah
353 8.7 Jo
354 8.9 Ah
358 8.5 Pc
360 8.6 Jo

R LEO
094211
364 9.1 Sf
364 8.4 Pt
365 8.6 Ah
368 8.4 Sz
368 8.6 Fd
371 7.7 Bc
377 8.9 Fd
377 8.1 Ma
378 8.7 Sf
383 8.6 Sf
383 8.2 Pc
383 8.7 Fd
386 8.5 Fd
384 8.0 Bg
387 8.5 Al
387 8.5 Mc

1 CAR
094262
326 3.9 Dr
360 4.0 Dr

Y HYA
094622
364 6.6 Pt

Z VEL
094953
312 8.7 Bl
324 9.9 En
326 9.2 Dr
332 9.7 Bl
333 9.9 En
339 9.7 Bl
368 10.4 Dr

V LEO
095421
364 11.5 Pt
377[13.5 Ma

RR CAR
095458
324 8.0 En

RV CAR
095563
324[12.5 En
332[13.1 Bl
368[13.6 Dr

S CAR
100661
312 6.8 Bl
324 8.0 En
326 7.9 Dr
329 8.0 Dr
332 7.8 Bl
333 8.7 En
339 7.9 Bl
349 7.0 Sl
353 6.7 Sl
357 6.5 Sl
357 6.4 Dr
368 6.0 Dr

VARIABLE STAR OBSERVATIONS RECEIVED DURING FEBRUARY, 1931.

J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs.

S CAR
100661
368 6.1 Sl

Z CAR
101058a
312 11.7 Bl
324 12.3 En
332 11.6 Bl
339 11.5 Bl
357 11.5 Dr
369 11.5 Dr

AF CAR
101058b
326 11.1 Dr
357 10.6 Dr
369 10.9 Dr

W VEL
101153
329 13.5 Dr
332 13.3 Bl
357 12.5 Dr

U HYA
103212
310 6.0 Kd
356 6.0 Kd
362 6.0 Kd
365 5.9 Kd
370 5.3 L

RZ CAR
103270
325[12.4 En
357[13.9 Dr

R UMA
103769
326 9.0 Fd
335 9.3 Fd
351 9.8 Ah
352 9.8 Ah
353 9.8 Ah
354 9.9 Ah
358 10.3 Pc
364 10.0 Pt
365 10.3 Ah
368 10.6 Fd
368 10.7 Sz
378 10.6 Mc
383 11.7 Fd
387 11.7 Al

V HYA
104620
332 7.8 Bl
339 7.4 Bl
348 7.4 L
364 7.8 Pt
370 7.6 L

RS HYA
104628
332 12.5 Bl
339 12.1 Bl

W LEO
104814
361 13.7 L
378[12.3 Ma

RS CAR
110361
349[12.3 Sl
357[12.3 Sl

S LEO
110506
346 11.3 L
364 11.8 Pt
369 11.9 L

RY CAR
111561
312[12.7 Bl
326[13.5 Dr
332[13.1 Bl
337[12.1 En
369[13.5 Dr

RS CEN
111661
312 10.0 Bl
326 8.8 Dr
332 8.3 Bl
337 8.6 En
339 8.4 Bl
357 8.4 Dr
369 9.2 Dr

X CEN
114441
326 11.1 Dr
332 11.2 Bl
339 11.4 Bl
357 12.3 Dr

AD CEN
114858
338 9.2 En
369 9.1 Dr

W CEN
115058
312 11.1 Bl
329 12.4 Dr
332 12.6 Bl
369 13.1 Dr

R COM
115919
364 13.5 Pt

SU VIR
120012
383[12.5 Bw

T VIR
120905
346 10.1 L
364 9.9 Pt
368 10.3 Pc

R CRV
121418
337 9.4 Kd
346 10.3 L

R CRV
121418
357 10.3 Sl
364 10.8 Pt
368 10.9 Sl
369 11.0 Kd
369 11.2 L
386 11.6 Fd

SS VIR
122001
347 8.0 L
369 8.3 L

T CVN
122532
364 11.0 Pt
368 11.7 Pc
383 11.8 Pc

Y VIR
122803
347 9.3 L
370 8.6 L

U CEN
122854
329 8.8 Dr
332 9.1 Bl
339 9.3 Bl
357 10.8 Dr

T UMA
123160
350 8.7 Jo
351 8.5 Ah
352 8.4 Ah
353 8.5 Ah
353 8.3 Jo
354 8.3 Ah
356 8.3 Jo
358 8.1 Pc
360 8.1 Jo
364 8.0 Pt
365 7.9 Ah
368 7.7 Fd
377 7.6 Fd
377 7.5 Ma
383 7.5 Fd

R VIR
123307
364 9.3 Pt
386 8.0 Fd

RS UMA
123459
350 10.4 Jo
353 11.0 Jo
356 11.3 Jo
358 11.3 Pc
360 11.4 Jo
364 11.8 Pt
377 12.8 Ma

S UMA
123961
350 8.4 Jo

S UMA
123961
351 8.3 Ah
352 8.4 Ah
353 8.3 Ah
353 8.6 Jo
354 8.5 Ah
356 8.7 Jo
358 12.0 Pc
360 8.9 Jo
364 9.1 Pt
365 8.9 Ah
368 9.7 Fd
377 9.8 Fd
377 9.6 Ma
383 10.0 Fd

RU VIR
124204
347 11.7 L
365 11.4 Pt
383 10.8 Bw

U VIR
124606
347 8.2 L
353 8.5 Ah
365 8.2 Pt
370 8.4 L
386 9.2 Fd

RV VIR
130212
370[13.8 L

U OCT
131383
332 13.1 Bl
337 12.4 En
339 12.1 Bl
357 11.2 Dr

V CVN
131546
367 8.4 GD
381 8.2 GD
386 8.5 GD

V VIR
132202
370[14.0 L

R HYA
132422
343 4.6 L
357 3.8 Sl
365 4.6 Pt
368 3.7 Sl
369 4.3 L

S VIR
132706
365 12.2 Pt
386[11.0 Fd

RV CEN
133155
332 7.8 Bl
339 7.7 Bl

T UMI
133273
351 13.7 Ke
354 12.6 L
358 12.3 Ke
366 11.8 Ke

T CEN
133633
357 7.3 Dr
357 7.5 Sl
368 8.2 Sl
369 8.0 Dr

RT CEN
134236
357 12.9 Dr

R CVN
134440
352 10.0 Ah
353 10.0 Ah
354 10.1 Ah
365 10.0 Pt

RX CEN
134536
357 10.4 Dr

T APS
134677
329[13.2 Dr
339[13.2 Bl

Z BOO
140113
361 14.4 L

Z VIR
140513
343 11.6 L
369 12.4 L

RU HYA
140528
357 12.5 Dr

R CEN
140959
329 7.5 Dr
332 8.1 Bl
339 7.7 Bl
353 7.3 Sl
357 7.4 Dr
368 6.9 Sl

U UMI
141567
352 11.2 Ah
353 11.5 Ah
354 11.4 Ah
365 11.2 Ah
365 12.4 Pt
368 12.0 Pc

S BOO
141954
347 11.5 L
373[12.0 L

RS VIR
142205
347 9.1 L
372 10.6 L

V BOO
142539a
352 8.8 Ah
353 8.7 Ah
354 8.8 Ah
366 9.2 Pt
368 9.5 Pc
383 9.9 Pc
383 9.8 Fd
386 9.9 Fd

R BOO
143227
370 13.6 L

Y LUP
145254
332 10.2 Bl
339 10.7 Bl
357 11.1 Dr

S APS
145971
353 11.7 Ah
366 11.0 Pt

V LIB
143417
329 9.9 Dr
332 10.1 Bl
339 10.1 Bl
357 9.9 Dr
368 9.7 Dr
369 9.8 Dr

RT LIB
150018
366 9.0 Pt

T LIB
150519
347 10.9 L
366 11.0 Pt
370 11.1 L

Y LIB
150605
343 9.5 L
361 8.6 L
366 8.7 Pt

S LIB
151520
346 10.3 L
369 11.2 L

S SER
151714
343 11.4 L
369 12.0 L

S CRB
151731
353 9.1 Ah
366 10.0 Pt
368 9.3 Pc

VARIABLE STAR OBSERVATIONS RECEIVED DURING FEBRUARY, 1931.

J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
S CrB	R Lib	SS Her	RT Sco	RY Her	X Oph
151731	*154715*	162807	*165636*	175519	183308
386 10.1 Fd	361[12.5 L	343 11.3 L	369 12.8 Dr	366 9.1 Pt	347 8.4 L
RS Lib	370[14.0 L	366 12.6 Pt	— Dra	369 9.1 L	366 8.8 Pt
151822	R Lup	369 13.1 L	165752	388 9.1 Ma	370 8.4 L
348 11.5 L	*154736*	T Oph	349 10.2 L	V Dra	RY Lyr
370 12.1 L	368 13.2 Dr	*162815*	R Oph	175654	184134
RU Lib	RR Lib	370 12.7 L	*170215*	348 9.9 L	352 14.1 L
152714	*155018*	S Oph	361 8.5 L	366 10.2 Pt	R Sct
347 8.3 L	347 9.4 L	*162816*	366 8.3 Pt	372 10.9 L	*184205*
366 7.8 Pt	366 9.7 Pt	348 9.2 L	RT Her	R Pav	264 6.5 Kd
370 8.0 L	370 10.5 L	370 9.1 L	170627	*180363*	293 6.5 Kd
R Nor	Z CrB	W Her	366 11.7 Pt	323 12.5 En	302 6.0 Kd
152849	155229	163137	370 11.9 L	368 8.5 Dr	322 5.9 Kd
368 7.1 Dr	369 14.5 L	366 11.5 Pt	RW Sco	T Her	346 5.0 L
W Lib	RZ Sco	386 11.9 Fd	*170833*	180531	361 5.4 L
153215	*155823*	R UMi	369 12.3 Dr	343 7.7 L	366 5.9 Pt
348 11.9 L	366 12.5 Pt	163172	Z Oph	366 8.5 Pt	369 5.5 L
361 12.1 L	Z Sco	350 10.6 Jo	171401	369 8.7 L	S CrA
S UMi	*160021*	353 10.5 Jo	366 11.5 Pt	386 11.5 Fd	*185437a*
153378	361 11.8 L	356 10.3 Jo	RS Her	W Dra	311 12.0 Bl
350 10.3 Jo	R Her	360 10.1 Jo	171723	180565	321[11.7 Bl
353 10.3 Jo	160118	R Dra	366 12.0 Pt	348 9.3 L	RT Lyr
358 10.5 Jo	366 9.5 Pt	163266	S Oct	366 9.0 Pt	185737
366 11.7 Pt	386 9.7 Fd	326 7.6 Fd	*172486*	372 9.7 L	352 13.9 L
T Nor	U Ser	342 7.8 Fd	320 11.7 Bl	X Dra	S Lyr
153654	160210	349 7.9 Fd	330 12.3 Bl	180666	190925
369 7.8 Dr	366 9.1 Pt	350 8.1 Jo	337 12.6 En	348 14.0 L	348 12.2 L
R CrB	386 8.5 Fd	351 8.4 Ah	RU Oph	366 10.8 Pt	372 12.8 L
154428	SX Her	352 8.3 Ah	*172809*	372 13.1 L	X Lyr
343 6.0 L	160325	353 8.3 Ah	366 12.5 Pt	TV Her	190926
346 5.9 L	343 8.5 L	354 8.6 Ah	369 14.0 L	181031	366 9.0 Pt
347 5.9 L	365 8.2 Pt	356 8.4 Jo	388 14.1 Ma	346 10.5 L	RS Lyr
348 6.0 L	366 8.1 Pt	360 8.3 Jo	RT Ser	369 9.9 L	190933a
349 6.0 L	369 8.7 L	364 8.5 Jo	*173411*	RY Oph	348 11.3 L
353 6.3 Ah	RU Her	365 8.9 Ah	370 12.5 L	181103	366 11.4 Pt
360 6.0 L	160625a	366 9.0 Pt	RU Sco	366 9.7 Pt	372 10.9 L
361 5.9 L	343 11.9 L	368 8.7 Fd	*173543*	W Lyr	RU Lyr
361 6.2 Kd	369 12.2 L	377 9.3 Fd	311 9.3 Bl	181136	190941
365 6.1 Pt	R Sco	386 10.3 Fd	320 9.6 Bl	349 7.6 L	348 10.9 L
366 6.1 Pt	*161122a*	RR Oph	369 11.6 Dr	350 8.0 Jo	358 11.0 Pc
368 6.1 Pc	366 12.6 Pt	*164319*	TV Sco	353 7.7 Jo	366 11.2 Pt
369 6.0 L	W CrB	370[13.0 L	*173643*	353 8.2 Ah	372 11.8 L
370 6.0 L	161138	S Her	369 11.6 Dr	356 7.7 Jo	U Dra
372 6.0 L	366 11.0 Pt	164715	SX Sco	366 7.8 Pt	190967
383 6.1 Pc	W Oph	366 11.7 Pt	*174035*	369 7.7 L	348 12.8 L
383 6.2 Pt	*161607*	RS Sco	369 7.5 Dr	SV Her	366 13.0 Pt
386 5.9 GD	370 13.1 L	*164844*	SV Sco	182224	RY Sgr
386 6.1 Fd	V Oph	368 11.6 Dr	*174135*	348 12.9 L	*191033*
X CrB	*162112*	RR Sco	311[11.0 Bl	366 13.4 Pt	321[11.6 Bl
154536	347 7.6 L	*165030a*	W Pav	SV Dra	368[10.8 Dr
343 8.9 L	366 8.6 Pt	357 8.7 Sl	*174162*	183149	369[10.8 Dr
366 9.9 Pt	372 8.1 L	368 8.0 Sl	332[12.1 Bl	348 10.2 L	TZ Cyg
369 9.4 L	U Her	368 8.0 Dr	369[13.4 Dr	372 12.0 L	191350
R Ser	162119	SS Oph	U Ara	388 12.4 Ma	366 10.5 Pt
154615	366 7.6 Pt	*165202*	*174551*	RZ Her	U Lyr
366 8.3 Pt	386 9.1 Fd	366 12.1 Pt	368 9.1 Dr	183225	191637
V CrB	Y Sco	RV Her	RT Oph	348[13.3 L	350 11.2 Jo
154639	*162319*	165631	175111		353 11.3 Jo
366 9.1 Pt	370[13.5 L	369 14.5 L	370 13.9 L		356 11.5 Jo

VARIABLE STAR OBSERVATIONS RECEIVED DURING FEBRUARY, 1931.

J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
U LYR	TU CYG	S CYG	V SGE	W AQR	T CEP
191637	194348	200357	201520	*204104*	210868
357 11.0 Rs	363 11.5 Rs	348 10.2 L	344 12.3 L	352 12.8 L	353 6.4 Ah
366 11.8 Pt	364 10.7 Jo	353 10.7 Rs	349 12.4 L	U CAP	353 6.5 Jo
AF CYG	388 12.3 Ma	356 10.8 Pt	350 12.6 L	*204215*	354 6.5 Ah
192745	X AQL	358 10.6 Pc	358 11.8 L	321[13.1 Bl	356 6.1 Pt
351 7.7 Ah	194604	363 10.7 Rs	U CYG	RZ CYG	360 6.5 Jo
352 7.6 Ah	370[11.6 L	370 10.7 Rs	201647	204846	364 6.6 Jo
353 7.7 Ah	χ CYG	377 10.7 Pc	326 7.4 Fd	356 12.5 Pt	365 6.6 Ah
369 6.8 Ah	194632	S AQL	341 7.6 Fd	S IND	368 6.5 Fd
TY CYG	279 9.5 Kd	200715a	349 7.9 Fd	*204954*	369 6.5 Ah
192928	291 9.6 Kd	350 11.8 Jo	350 7.6 Jo	321 13.2 Bl	377 6.8 Fd
348 13.4 L	356 11.8 Pt	356 11.7 Pt	353 7.5 Jo	332 13.7 Bl	383 6.8 Fd
RT AQL	359 12.0 Bg	RW AQL	356 7.0 Pt	X DEL	386 7.0 Fd
193311	363 12.3 Bg	200715b	357 7.6 GD	205017	RR AQR
350[13.2 L	S PAV	350 9.5 Jo	358 7.4 Jo	349 8.9 L	*210903*
R CYG	*194650*	356 9.2 Pt	364 7.5 Jo	356 8.6 Pt	349 12.2 L
193449	323 8.6 En	R TEL	364 7.7 GD	R VUL	X PEG
326 11.5 Fd	RR SGR	*200747*	377 7.9 Fd	205923a	211614
339 11.2 Tf	*194920*	321[13.5 Bl	U MIC	350 9.0 Jo	350 9.1 L
341 11.4 Fd	321 11.6 Bl	W CAP	*202240*	352 9.2 Ah	356 9.8 Pt
349 12.0 Fd	332 10.6 Bl	*200822*	321[13.0 Bl	353 9.3 Ah	358 9.5 Pc
350 11.8 Jo	RU SGR	321[12.8 Bl	Z DEL	353 9.3 Jo	358 9.0 L
352 12.0 Jo	*195142*	R SGE	202817	356 9.4 Pt	T CAP
353 12.2 Tf	321 7.2 Bl	200916	349[13.9 L	358 9.8 Jo	*211615*
356 11.6 Pt	330 7.6 Bl	350 10.5 Jo	ST CYG	360 10.0 Jo	311 11.7 Bl
388 12.6 Ma	339 8.0 Bl	RS CYG	202954	V CAP	321 10.9 Bl
T PAV	RR AQL	200938	350 13.9 L	*210124*	332 9.9 Bl
193972	*195202*	348 7.3 L	356 13.0 Pt	311 9.8 Bl	339 9.8 Bl
321 11.7 Bl	370 9.8 L	350 7.0 Jo	V VUL	321 9.9 Bl	S MIC
323 11.5 En	NOV CYG	353 7.1 Jo	203226	332 9.9 Bl	*212030*
329 11.7 Dw	195553	356 7.0 Pt	356 8.8 Pt	339 10.4 Bl	311 10.2 Bl
330 11.8 Dr	353[12.4 Rs	358 7.0 Jo	R MIC	TW CYG	320 11.0 En
330 12.3 Bl	356[12.2 Pt	358 7.2 L	*203429*	210129	321 11.1 Bl
368 13.4 Dr	366[12.2 Pt	362 7.1 Bg	321[12.8 Bl	350 14.7 L	332 12.4 Bl
RT CYG	377[12.2 Pt	364 7.3 Jo	Y DEL	X CAP	Y CAP
194048	RR TEL	R DEL	203611	*210221*	*212814*
326 6.5 Fd	*195656*	201008	349 12.3 L	311 10.7 Bl	321[13.1 Bl
341 6.8 Fd	323[12.6 En	349 8.6 L	S DEL	321 10.7 Bl	W CYG
349 7.6 Fd	Z CYG	356 8.5 Pt	203816	332 11.2 Bl	213244
350 7.7 Jo	195849	RT CAP	356 9.6 Pt	339 11.1 Bl	264 6.5 Kd
351 7.5 Ah	320 9.1 Ke	*201121*	V CYG	X CEP	276 6.6 Kd
352 7.5 Ah	327 8.9 Ke	292 7.5 Kd	203847	210382	322 6.6 Kd
353 7.5 Ah	328 8.8 Ke	322 7.6 Kd	350 9.9 L	350 14.5 L	330 6.4 Kd
353 7.5 Jo	341 8.5 Ke	SX CYG	356 9.1 Pt	RS AQR	333 6.4 Kd
356 7.7 Pt	343 8.6 Ke	201130	358 9.7 Pc	*210504*	349 6.0 L
358 7.5 Jo	345 8.4 Ke	350 12.9 L	373 10.6 L	349 12.4 L	355 6.4 Kd
364 7.9 Jo	348 8.6 L	RT SGR	377 10.6 Pc	R EQU	358 6.1 L
369 8.3 Ah	353 8.9 Rs	*201139*	T DEL	210812	S CEP
377 8.5 Fd	356 8.5 Pt	311 11.7 Bl	204016	350 13.2 L	213678
377 8.5 Pc	363 8.9 Rs	321 12.4 Bl	349 10.1 L	356 13.8 Pt	356 9.5 Pt
386 9.0 Fd	370 8.9 Rs	332[12.7 Bl	356 9.5 Pt	T CEP	RU CYG
TU CYG	S TEL	WX CYG	U DEL	210868	213753
194348	*195855*	201437b	204017	326 5.9 Fd	351 9.0 Ah
348 11.0 L	321 13.1 Bl	348 12.3 L	330 6.7 Tf	335 6.0 Fd	352 9.0 Ah
350 10.3 Jo	323[12.6 En	353 12.3 Rs	339 6.9 Tf	341 6.0 Fd	353 9.0 Ah
353 10.3 Jo	SY AQL	356 12.6 Pt	353 6.7 Tf	349 6.1 Fd	356 8.7 Pt
353 11.0 Rs	200212	358 12.3 L	V AQR	350 6.3 Jo	366 9.5 Bw
356 10.9 Pt	349 10.7 L	363 12.1 Rs	204102	351 6.4 Ah	
358 10.4 Jo	356 11.8 Pt		349 8.9 L	352 6.5 Ah	

Variable Star Observations Received During February, 1931.

J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
RR Peg	T Gru	T Tuc	S Peg	R Aqr	V Cet
214024	*221938*	*223462*	231508	*233815*	*235209*
357 12.8 Pt	320 10.1 En	332 11.7 Dr	357 11.3 Pt	293 8.7 Kd	339 11.8 Bl
R Gru	325 9.8 En	351 9.8 Dr	V Phe	312 8.9 Bl	349 13.0 L
214247	S Gru	R Lac	*232746*	320 8.9 En	R Tuc
312 12.5 Bl	*221948*	223841	320[13.2 En	321 9.1 Bl	*235265*
320 12.0 En	320[12.8 En	352 14.6 L	332 13.9 Dr	330 8.9 Bl	320 10.8 En
321 12.1 Bl	329[14.0 Dw	RW Peg	337[12.7 En	330 9.1 Tf	332 11.9 Dr
325 11.8 En	330[13.9 Dr	225914	Z And	333 8.9 Kd	333 12.4 En
332 10.9 Dr	RV Peg	349 11.5 L	232848	339 9.1 Tf	351 13.4 Dr
332 11.1 Bl	222129	357 11.5 Pt	353 9.7 Rs	339 9.1 Bl	R Cas
339 9.7 Bl	349 12.8 L	358 12.0 L	357 9.8 Pt	349 8.9 L	235350
V Peg	S Lac	β Peg	360 9.8 Rs	353 9.2 Tf	351 8.2 Ah
215605	222439	225927	360 9.4 Bg	355 8.9 Kd	352 8.2 Ah
349 8.8 L	334 8.0 Th	378 2.6 Mc	364 9.9 Rs	357 9.4 Pt	353 8.0 Ah
357 8.1 Pt	336 8.0 Th	387 2.8 Mc	370 9.8 Rs	Z Cas	354 7.9 Ah
RT Peg	339 7.7 Tf	R Peg	384 9.7 Bg	233956	365 6.4 Ah
215934	347 7.5 L	230110	384 10.3 Md	350 14.6 L	377 6.0 B
349[14.0 L	351 8.1 Th	357 12.0 Pt	392 10.3 Md	382 13.3 Mg	Z Peg
358[14.5 L	353 7.9 Tf	360 12.5 Bg	ST And	RR Cas	235525
RZ Peg	357 7.9 Pt	V Cas	233335	235053	349 11.7 L
220133b	360 8.5 Th	230759	349 10.6 Fd	379 11.2 B	357 10.7 Pt
347 11.7 L	361 7.9 L	357 10.7 Pt	357 10.5 Pt	388 11.2 Md	Y Cas
357 11.3 Pt	366 8.7 Mg	364 10.6 Rs	358 10.4 BL	R Phe	235855
361 11.6 L	377 9.1 Mg	378 11.2 B	362 10.5 BL	*235150*	348 13.0 L
T Peg	387 10.4 Md	W Peg	366 10.1 Mg	320 9.0 En	353 12.8 Rs
220412	R Ind	231425	368 10.0 Fd	332 9.8 Dr	361 12.1 L
350 10.8 L	*222867*	347 12.4 L	370 10.5 BL	V Cet	SV And
358 11.0 Pc	320[13.5 En	361 12.4 L	375 10.4 BL	*235209*	235939
RS Peg	321[13.5 Bl	382 12.1 Mg	377 10.1 Mg	312 11.1 Bl	357 10.9 Pt
220714	332[13.0 Dr	S Peg	378 9.8 B	321 11.2 Bl	377 10.5 Mg
350 13.5 L	351[13.4 Dr	231508	378 10.3 BL	330 11.6 Bl	384 9.8 Md
		349 11.2 L	384 10.2 BL		393 9.4 Md

Rapidly Varying Irregular Variables.

Star J.D.	Est.Obs.	J.D.	Est.Obs.	Star J.D.	Est.Obs.	J.D.	Est.Obs.
005840 RX Andromedae—				060547 SS Aurigae—			
6333.1	13.1 Ch	6359.6	13.2 Pt	6370.3	[12.4 L	6383.7	[13.2 BG
6348.4	13.1 L	6360.6	12.8 Rs	6373.3	[12.4 L		
6349.4	13.2 L	6361.3	13.1 L	074922 U Geminorum—			
6350.4	13.2 L	6364.6	13.0 Pt	6343.7	[12.4 L	6362.1	13.5 Sl
6352.3	10.2 L	6364.6	12.9 Rs	6346.7	[9.8 L	6363.6	[12.5 Rs
6353.3	10.3 L	6365.6	10.9 Pt	6347.4	[11.4 L	6364.6	[12.4 Pt
6353.6	10.9 Rs	6366.3	10.6 L	6348.3	13.9 L	6365.9	[12.4 Pt
6354.3	10.5 L	6366.6	10.9 Pt	6349.7	13.8 L	6366.3	13.6 L
6356.6	11.7 Pt	6369.4	11.0 L	6350.4	13.7 L	6368.6	13.8 BG
6357.3	12.1 L	6373.3	12.9 L	6352.4	13.7 L	6369.3	13.7 L
6357.7	12.6 Pt	6376.6	[11.8 Pt	6352.7	13.9 L	6370.3	13.7 L
6358.4	12.4 L	6377.6	13.2 Pt	6353.1	13.7 Sl	6372.7	[12.4 L
6358.6	13.0 Pt	6378.6	13.1 Pt	6353.4	13.7 L	6373.4	[12.4 L
060547 SS Aurigae—				6353.6	12.9 Rs	6376.6	[11.7 Pt
6343.7	[12.5 L	6352.4	10.8 L	6354.3	13.7 L	6377.6	[12.4 Pt
6344.2	[12.5 L	6352.7	11.1 L	6356.0	13.7 Sl	6378.7	[13.3 Ma
6346.7	[12.5 L	6353.4	11.0 L	6357.3	13.8 L	6379.6	14.0 B
6347.3	[13.6 L	6354.3	11.0 L	6358.3	13.6 L	6383.8	14.1 Ma
6348.3	14.4 L	6357.3	13.0 L	6360.6	14.1 L	6384.7	[13.3 BG
6348.7	[13.9 L	6358.3	[13.9 L	6361.3	13.8 L	6388.8	14.0 Ma
6349.4	14.2 L	6360.7	14.3 L	081473 Z Camelopardalis—			
6349.7	[12.4 L	6366.3	14.6 L	6343.7	11.3 L	6346.7	11.5 L
6350.3	14.2 L	6369.3	14.2 L	6344.2	11.4 L	6347.4	11.8 L

VARIABLE STAR OBSERVATIONS RECEIVED DURING FEBRUARY, 1931.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.
081473 Z CAMELOPARDALIS—							213843 SS CYGNI—						
	6348.4	11.7	L	6358.7	11.5	L		6343.6	12.0	Ke	6359.5	12.0	Bg
	6349.4	12.0	L	6361.3	12.0	L		6344.2	12.2	L	6359.6	11.7	Pt
	6349.7	11.7	L	6365.3	12.0	L		6345.6	11.8	Ke	6360.5	12.0	Bg
	6350.4	12.0	L	6366.3	12.0	L		6347.3	12.0	L	6360.6	11.8	Jo
	6352.4	12.0	L	6369.3	11.8	L		6348.3	12.0	L	6361.3	12.1	L
	6353.4	12.0	L	6370.3	11.8	L		6349.3	12.1	L	6362.5	12.0	Bg
	6354.4	11.6	L	6372.7	12.0	L		6349.5	11.7	Fd	6363.5	12.0	Bg
	6357.3	11.7	L	6373.8	12.0	L		6350.3	12.0	L	6364.6	12.0	Jo
	6358.2	12.0	L					6350.6	11.8	Jo	6364.6	11.7	Pt
094512 X LEONIS—								6351.2	11.8	Ah	6365.2	12.1	L
	6343.7	12.6	L	6369.7	12.2	L		6351.6	11.3	Ke	6366.3	12.1	L
	6346.7[	12.3	L	6370.4	12.1	L		6352.2	11.8	Ah	6366.6	12.0	Mg
	6350.4[	13.8	L	6370.7	12.3	L		6352.2	12.1	L	6366.6	11.7	Pt
	6366.3	12.1	L	6372.7[	14.0	L		6352.6	11.8	Jo	6368.6	11.7	Fd
	6369.3	12.3	L					6353.2	12.0	Ah	6369.3	12.1	L
202946 SZ CYGNI—								6353.3	12.1	L	6370.4	11.9	L
	6356.6	9.0	Pt	6366.6	9.6	Pt		6353.6	11.6	Jo	6370.7	12.0	L
	6357.7	9.0	Pt	6375.7	9.5	Pt		6354.3	12.1	L	6372.7	12.1	L
	6358.6	9.0	Pt	6376.6	9.5	Pt		6354.5	11.5	Bc	6373.3	12.1	L
	6359.6	9.2	Pt	6377.6	9.4	Pt		6356.6	11.6	Jo	6375.7	11.7	Pt
	6364.6	9.7	Pt	6378.6	9.4	Pt		6356.6	11.6	Pt	6376.6	11.7	Pt
213843 SS CYGNI—								6357.3	12.1	L	6377.6	11.5	Pt
	6303.6	11.6	Ke	6327.6	8.8	Ke		6357.7	11.7	Pt	6377.6	11.7	Fd
	6309.6	12.0	Ke	6328.6	8.6	Ke		6358.3	12.1	L	6377.6	11.8	Pc
	6311.6	11.9	Ke	6331.6	9.3	Ke		6358.6	11.7	Jo	6378.6	11.6	Pt
	6313.6	11.9	Ke	6341.5	11.5	Fd		6358.6	11.9	Pc	6383.6	11.3	Fd
	6320.6	12.0	Ke	6341.6	11.9	Ke		6358.6	12.0	Ke	6388.9	11.9	Ma
	6326.5	8.5	Fd	6342.5	11.4	Fd		6358.6	11.7	Pt			

SUMMARY FOR THE MONTH OF FEBRUARY, 1931.

Observer	Initial	Vars.	Observations	Observer	Initial	Vars.	Observations
Ahnert	Ah	35	129	Kline	Ke	6	28
Allen	Al	5	6	Lacchini	L	176	394
Baldwin	Bl	73	176	Marsh	Ma	30	41
Bigelow	Bw	12	16	McLeod	Mc	8	12
Boutell	BL	11	73	MacPherson	Mp	5	8
Bouton	B	32	32	Millard	Md	12	16
Buckstaff	Bc	3	3	Monnig	Mg	19	22
Bunting	Bg	17	29	Peltier	Pt	175	240
Chandra	Ch	42	55	Proctor	Pc	27	40
Dartayet	Dr	75	126	Ross	Rs	11	23
Dawson	Dw	11	11	Shinkfield	Sl	18	47
Ensor	En	57	90	Shultz	Sz	3	3
Ford	Fd	46	120	Smith, F. W.	Sw	11	38
Godfrey Club	GD	6	13	Taffara	Tf	16	40
Guiler	Gc	4	4	Theile	Th	5	17
Jones	Jo	43	145				
Kanda	Kd	12	40	Totals		32	409	2037

LEON CAMPBELL, Recording Secretary.

March 12, 1931.

NOTES FROM AMATEURS

A Calendar for Posterity.—There seem to be many good reasons for the adoption by the civilized world of a thirteen month calendar and few, if any, good ones for its non-adoption. The gain to posterity would be very great—would, indeed, much more than counterbalance the slight inconvenience which the present generation might experience temporarily. However, as habit is deeply ingrained in the human race, we shall probably continue to use it for the same reason—or lack of reason—for which we continue to use our cumbersome system of weights and measures, notwithstanding the fact that we must realize the great advantage to be gained by the adoption of the metric system.

But regardless of the way in which we may divide and subdivide the year into months and weeks, the length of the tropical year remains the same—365 days, 5 hours, 48 minutes, 45.92 seconds.

As is well known, the Julian calendar disegarded the difference between the actual length of the year and 365¼ days, and this small difference had amounted to ten days in 1582 when Pope Gregory took account of it by decreeing that only century years divisible by 400 should be regarded as leap years. This makes the calendar year and the tropical year agree very closely unless one takes into account a very long period of time. By taking account of the difference of 11 minutes 14.08 seconds we find that in one hundred years the calendar year is slow as compared with the tropical year by an amount equal to 1123 minutes 28 seconds. After correcting for this difference by omitting the century leap year we find that the calendar year is then 316 minutes 32 seconds fast, and at the end of the fourth century this difference has increased to 1266 minutes 8 seconds by which amount the calendar year is now too fast as compared with the tropical year.

Since the fourth century year is a leap year, after making this correction we find that the calendar year is again 173 minutes 52 seconds slow.

Should we therefore apply the Gregorian calendar for four thousand years our calendar would then be 1738 minutes 40 seconds, or slightly more than a day, slow. This could be corrected by considering all years which are multiples of 4000 not as leap years, as they are according to the Gregorian calendar. Making such omission, the calendar year is still slow by an amount equal to 298 minutes 40 seconds, an average loss of 4.48 seconds per year. In this connection it is interesting to note that the error in the Gregorian calendar amounts to one day in approximately 3300 years, whereas if only the century years which are multiples of 500, instead of 400, were considered as leap years the discrepancy would not amount to a day until the lapse of more than 5000 years.

In twenty thousand years the error with the proposed modification would amount to 1493 minutes 20 seconds, by which amount the calendar would be slow as compared with the tropical year. This could be corrected by not only not considering the year 20,000, which is a multiple of 4,000, as a leap year but also by shortening it an extra day. For example, December, or any one of the long months, might contain but thirty days, or the year 22000 might not be considered as a leap year. Making such correction we find that the calendar year is now slow by an amount equal to 53 minutes 20 seconds, an average of approximately one-sixth of a second per year for the period of twenty thousand years.

On this basis the calendar year will be slow by an amount equal to 1333 minutes 20 seconds after a period of half a million years, and correction being made for this difference as in the preceding cases the calendar year would then be fast

by an amount equal to 106 minutes 40 seconds, an average of .00128 seconds per year, or about one second in seventy-five years.

This difference would amount to a day in slightly less than seven million years at the end of which time the need of a calendar may have ceased to exist.

During this period of time the length of the day will probably have undergone a change, which will be nearly, if not quite, inappreciable. Certainly it will not have suffered sufficient change to invalidate the above reasoning.

It is interesting to note that were the thirteen-month calendar adopted with its additional month in mid-summer, the extra day of the ordinary year being added to December, with the leap-day added to the extra month, Sol, in mid-summer, it would be a very simple matter to omit the leap-day for years which are multiples of four thousand as well as for those which are not multiples of four hundred, thus having twelve months of equal length—twenty-eight days—and a thirteenth one with an extra day.

In case it became necessary to omit two days, as after twenty thousand years, we would have thirteen months of twenty-eight days each, and only after half a million years would we have a final month of twenty-seven days.

But were we to apply this plan it would be nearly seventy million years before a discrepancy of ten days would arise and hence the need of another Pope Gregory to revise our calendar, even if the suggested correction at the expiration of half a million years were not applied.

W. E. Anderson.

Miami University, Oxford, Ohio.

ZODIACAL LIGHT NOTES

By W. E. GLANVILLE.

During the past month cloudy weather at this station has been almost continuous. Only on the following dates were observations possible: February 14, 15, and March 13.

Evening Zodiacal Light.—On February 14 at 7:45 P.M. the southern third of the Square of Pegasus was covered by the Light which extended to a boundary line 5° north of Beta Ceti and gave a horizon breadth of about 30°. The Light was strong to Aries, thence faint to the Pleiades. At 8:45 the volume of the Light was about the same as at 7:45 but the whole body was quite faint. Alpha Andromedae was clear of the Light; the remaining visible part of the Square of Pegasus was covered by the Light. At this time the space between Aries and Mu Ceti was slightly more than half covered, Gamma Arietis being on the north boundary. By turning towards Gemini and then slowly looking westward the very faint apex was seen 5° east of the line joining the center of the Pleiades and the Hyades. On February 15 the sky was perfectly clear at 7:15 P.M. when the Light showed strong, much brighter than the Cassiopeia-Cygnus section of the Milky Way. Along the horizon the Light extended from the south boundary of the Square of Pegasus to 8° north of Beta Ceti. Thence it narrowed through the space between Aries and Mu Ceti, occupying about half of that area. The apex was noted a few degrees west of the Pleiades. At 8:45 the volume of the Light was much the same as at 7:15. What remained in view of the Square of Pegasus was entirely covered to Alpha Andromedae. At this time Gamma Arietis was on the north boundary and the Light was broader between Gamma Arietis and Mu Ceti than it was at 7:15. The Pleiades were well within the Light. At 10:00

P.M. the whole body of the Light was exceedingly faint but it was seen without difficulty by contrast with the dark area between Aries and Cassiopeia. The space between Aries and Mu Ceti was now fully covered and the Aries asterism was within the north boundary. Slight fluctuations were seen near the Pleiades. On March 13 at 7:15 P.M. with a clear sky and normal twilight still lingering the outline of the Light was visible, being brighter than the adjacent areas north and south. At 7:35 twilight had disappeared and the apex of the Light was seen in the Pleiades. Beta and Gamma Arietis were just within the north boundary. About two-thirds of the space between Aries and Mu Ceti was covered. Thence the cone broadened to the horizon where the estimated breadth was 30°. At 8:45 the Light was very dim.

GEGENSCHEIN.—On March 13 at 11:00 P.M. the Gegenschein was observed along the ecliptic south of Denebola. The boundary was very diffuse. So far as could be traced the diameters were 15° east and west and 8° north and south.

FLUCTUATIONS.—During observations on the night of February 15 the scintillations of the Orion and Canis Major constellations were extraordinarily vivid and beautiful. The pulsing light of the bright stars produced an impression of rare majesty. The air was intensely clear. During the first half of the day the temperature had been below freezing and a keen northwest wind blew. Towards 3:00 P.M. came a sudden change. The wind ceased, the temperature rose to 45°, the weather became springlike and so continued during the night. At 10:00 P.M. fluctuations in the brightness of the eastern section of the Light were unmistakable. They appeared like the fluttering of a banner in a gentle breeze. No fluctuations were noticed in the lower half of the Light. The suggestion is offered that the fluctuations may be due to atmospheric conditions, particularly abrupt temperature variations at different elevations above the earth's surface. In his section on Zodiacal Light in the *Cosmos*, Baron von Humboldt refers to the striking Zodiacal Light pulsations he had seen in the tropics and quotes from a letter written to him by Dr. Olbers, March 26, 1833, as follows: "You are certainly right in ascribing those rapid variations in the light of the heavenly bodies which you have perceived in tropical climates to our own atmosphere and especially to its higher regions." Pulsations and fluctuations have been most frequently noted in tropical latitudes and at sea.

The Rectory, New Market, Maryland.

GENERAL NOTES

Sir Charles A. Parsons, the head of the firm which is well known for the astronomical apparatus which it has constructed, died on shipboard in the harbor of Kingston, Jamaica, on February 11.

Professor A. H. Joy, of the Mount Wilson Observatory, was elected president of the Astronomical Society of the Pacific, at the annual meeting on January 31. (*Science*, March 13, 1931.)

Dr. Svein Rosseland, who has recently returned to Norway after a year's work at Harvard University, will organize an institute in Oslo for theoretical astronomy. The Storthing has granted special facilities to Dr. Rosseland, with funds for a building and endowment. (*Science*, March 13, 1931.)

Dr. Holger Thiele, of the astronomical department of the University of California, has been appointed by Northwestern University research associate at Dearborn Observatory for a number of months. He is assisting the other members of the staff in various phases of the study of Eros. (*Science,* March 13, 1931.)

Mr. David B. Pickering, who is well known to readers of POPULAR ASTRONOMY through his interesting series of papers under the title "The Astronomical Fraternity of the World," has recently sailed from New York to Los Angeles by way of the Panama Canal. He will travel eastward leisurely, taking time to visit the various astronomical centers on the way. As a result of this pilgrimage we are looking forward to another series of papers from Mr. Pickering, which shall bring our own observatories as vividly before us as the former series brought those of Europe to us.

The University Association for the Study of Calendar Reform has been organized by a group interested in improving the calendar, but not committed in advance to some particular plan of alteration. The members of this association believe that, following the experimental method of modern science, there should be a trial, without legislative alteration, of various proposals, and a study of the results before any overhauling of the calendar is recommended. It has been pointed out that business men and others can obtain the essential advantages by a simple plan which does not require a League of Nations agreement, an act of Congress, or any legislation whatever, and as a first step in the study of calendar simplification, the trial of such a plan by persons interested is suggested. R. C. Flickinger, of the University of Iowa, Iowa City, Iowa, and Jakob Kunz, of the University of Illinois, Urbana, Illinois, are joint chairmen. C. C. Wylie, of the University of Iowa, Iowa City, Iowa, is Secretary-Treasurer.

Astronomical Tours.—The total solar eclipse visible in the northeastern part of the United States and Canada on August 31, 1932, and the meeting of the International Astronomical Union to be held in Cambridge, Massachusetts, immediately after the eclipse will be the occasion for a visit to the United States and Canada on the part of many astronomers. The Royal Astronomical Society is arranging two tours to include the points of greatest interest to astronomers. Tour "A" will cross Canada to the western coast and return across the United States. Tour "B" will be limited to eastern Canada and northeastern United States, going as far west as Toronto and Niagara Falls and as far south as New York City.

Persons on this side of the Atlantic will be welcome to join either of the tours. Full information as to cost and other details may be secured from Miss K. Williams, Assistant Secretary, The Royal Astronomical Society, Burlington House, London, W. 1.

The American Association for the Advancement of Science is this year launching the plan of holding annually a summer meeting of really national character. The first of these meetings will be held in Pasadena, California, from June 15 to 20, inclusive. The 1932 meeting goes to New Haven, the 1933 meeting to Chicago, and that of 1934 to San Francisco.

Plans for the Pasadena meeting are now well under way. The main features follow rather closely the precedent set by the British Association. These are: 1. Meetings extending through a full week. 2. Scientific sessions chiefly in the morning, and emphasis at these sessions on symposia. 3. Afternoons devoted

mainly to opportunities for discussion and personal contact through large numbers of excursions. 4. Popular addresses each evening, given if possible to a large audience, the speaker in each case being a man of as large national or international reputation as can be obtained.

Astronomy (Section D) will be well represented in the program, since the Astronomical Society of the Pacific, a very strong affiliated society, will meet with the association at Pasadena. This is in accordance with information given out by Charles F. Roos, Permanent Secretary.

Staronomy vs. Astronomy.—There is no conflict between the two. *Star*onomy is but the kindergarten of *Astr*onomy.

If you know the planets and prominent stars by name and by sight, and also the State name of each star on Old Glory, you are a *star*onomer. If you know that much (and much more!), you are an *astr*onomer.

A *star*onomer knows how to tell the time by a watch. An *astr*onomer not only knows that, but also how and why the watch goes.

Any lover of the great outdoors, with its birds, trees, flowers, etc., can easily become a delighted *star*onomer.

HENRY DILL BENNER.
Director, Forest Hill Night-Sky Club.
77 Heller Parkway, Newark, N. J.

BOOK REVIEWS

Measures of Double Stars, by Francis P. Leavenworth. (Publications of the Astr. Obs., Univ. of Minnesota, Vol. I, University of Minnesota Press, pp. 118, 1930.)

I remember Professor Leavenworth's last visit to Williams Bay a year before his lamented death. We were looking over some double-star publications, especially Comstock's Volume 10 of the Publications of the Washburn Observatory in which all his double-star work had been collected. I recall how pleased the gentle, venerable man seemed with my suggestion that he too should gather the fruit of his nightly vigils during forty years. A number of recent observations were unpublished and the others were scattered through many volumes, some of which were not generally available. However, circumstances did not allow him to see this hope fulfilled. It fell upon his successors to materialize this wish in this fine volume, No. 1 of the publications of the Astronomical Observatory at Minneapolis.

A short introduction and a biography precedes the long list of observations which covers 92 quarto-pages. The general majority of the measures were made with the 10½-inch refractor at Minneapolis and their quality has long been appreciated by double-star workers. A 16-page appendix contains the measures made with the same instrument by the late W. O. Beal during the years 1914-1929.

A fine photograph of Leavenworth is in frontispiece and a complete list of his publications is given. A more appropriate memorial to Leavenworth's long devotion to astronomy could not have been found.

G. VAN BIESBROECK.

Differential Equations, by Forest Ray Moulton, Ph.D., Sc.D. (The Macmillan Company, 1930, New York. xv + 395 pp.)

Dr. Moulton's *Differential Equations* exhibits the requisite originality in content and in method to make it an outstanding work in its field, in spite of the extensive related literature. Very properly the book does not consider the elements of differential equations, which have been adequately treated by so many authors. Dr. Moulton, in his book, has gathered together from inconveniently separated sources an important body of correlated theorems concerning the existence, properties, and construction of the solutions of various general classes of systems of ordinary differential equations at regular points. The subject matter is limited to a consideration of solutions subject to given *initial* conditions, not to general *boundary* conditions. The main content of the book furnishes a complete and indispensable foundation for one who would work intelligently in the field which the author selected for treatment. Although the book is concerned largely with classical results, the author has incorporated original methods in many places, and also certain interesting original results which he has never published in detail elsewhere.

The book is unique because of its choice of topics, its clear and rigorous exposition, its emphasis on the practical side of the subject, and its pedagogical completeness. Only one with Dr. Moulton's unique research experience could have made such a desirable selection of material as we find in this book. With great skill he puts life into the theory and exhibits its power in applications. He presents existence theorems, together with interesting illustrations, in such a manner that the reader easily appreciates that the theorems are actual tools,—not merely existence theorems. The major applications considered, which comprise about one-third of the book, are by no means obvious and trivial illustrations of general results. These applications are solutions of certain important problems of physics, astronomy, and pure mathematics which distinctly deserve attention on their own merits.

The style of the book suits it admirably either for intensive private study or for use as a text book. The main content is written on the level of one with essentially the mathematical maturity attained in an introductory course in the theory of functions of real and of complex variables. There are numerous exercises, historical notes and full references to outside literature. Many of the exercises are designed to extend the theoretical horizon of the reader beyond the limits attained in the text. In order to assist a reader whose foundation in analysis is incomplete, there are suggestive problems in the exercises, a whole chapter on certain phases of the theory of implicit functions, and various proofs in an appendix.

The greater part of the contents of the book was presented at various times by Dr. Moulton during the last twenty years in his lectures on differential equations at the University of Chicago. In these lectures he considered not only the contents of his present book but also partial differential equations and certain parts of the theory associated with the singular points of differential equations. The excellence of the present book makes one hope that Dr. Moulton will incorporate the additional portions of his lectures in future books devoted to differential equations.

William L. Hart.

University of Minnesota.